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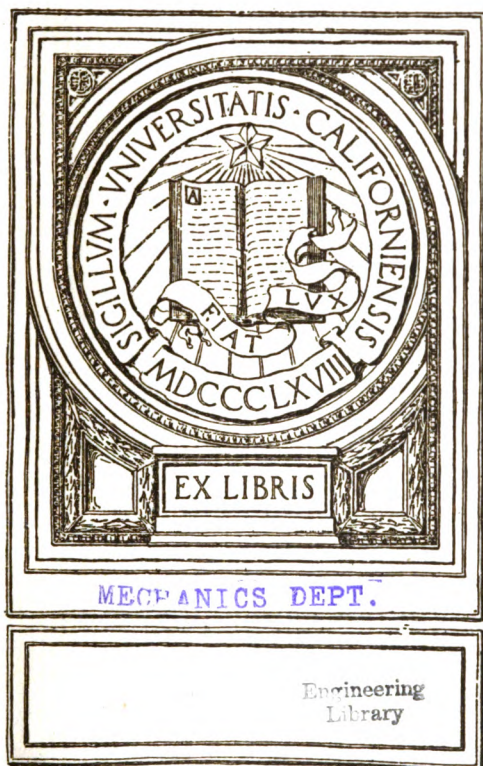
TECHNICAL NOTES
—
ROYAL FLYING CORPS







SCHOOL OF MILITARY AERONAUTICS,
UNIVERSITY OF CALIFORNIA,



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TECHNICAL NOTES, R.F.C.



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MECHANICS DEPT.

PHOTOGRAPHY.

INSTRUCTIONS FOR USE OF CHANGING BOX OF R.F.C. CAMERA.

1. Insert empty box on under side of camera, and pull out cover.
2. Push handle right "in" so as to set shutter, and get dial to show 0.
3. Insert box full of plates, with changing knob still right "in," withdraw cover slowly for about half an inch, and then quickly the rest of the way.
4. Return changing knob smartly home or "out," so as to bang against the end. This return movement must be done smartly.

ALL IS NOW READY TO TAKE PHOTOS.

To operate camera in air :—

1. Pull release. This takes the photo.
2. Grasp knob and push towards the middle slowly for two-thirds of the way, and then, not quickly but firmly, right home; this will change the plate and set the shutter. The shutter is set only if the word "set" is visible on the tell-tale at the side of the camera, on the reverse side of the release.

Having satisfied yourself that the shutter is set, bring the knob back quickly and firmly, so as to bang against the back.

3. Pull release for second photo, and continue above operations.
4. The number of photos taken will show on the dial.
5. On descending, pass all the plates into the "exposed box," as top box cannot be taken off till this is done.
6. Push in cover to "exposed box" and withdraw. Send in to be developed, stating how many taken.

WARNING.

Do not practice with plates that are to be used, as the process of changing them from one box to the other, reverses the way they lie in the box.

FULL TENSION should NOT be used on these cameras, never more than half at the most, as otherwise too much work comes on the setting string.

The shutter is changed as to slit in the usual way, and can be got at by pulling bead at end of guide to shutter setter, situated under disc.

INSTRUCTIONS FOR USE OF AEROPLANE CAMERA WITH MACKENZIE-WISHART SLIDE.

The camera is a delicate instrument and must be manipulated with great care.

Before Reconnaissance :—

1. Gently polish outside surface of lens with chamois leather, taking care not to close the diaphragm.

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2. Unscrew Mackenzie-Wishart slide, press exposure trigger, slide out slide, press down safety pin between velvet and winding knob with forefinger of left hand. Press inwards and then revolve the large milled head winding knob with right hand, and when slit is central, maintain pressure on knob with left hand, leaving right hand free to slide the index or edge of blind to required width of slit. Then release.

3. Wind up small tension milled head to the limit, so that the finger points to H on the dial on opposite side of the camera.

4. Replace M.-W. adapter and locking screw, taking care to press down safety knobs near velvet while doing so.

In Machine :—

5. Two rough satchels (Willesden cloth) should be hung, one on each side of the photographer inside the nacelle, the left hand satchel for unexposed plates, and the right hand one for exposed plates. By this means the same plate will not be exposed inadvertently a second time.

6. Just prior to arrival at area to be photographed, wind shutter. Slide long bolt of M.-W. adapter, and open back door of the adapter. Place envelope well over to the left, white disc uppermost, so that small batten on envelope engages in groove. Close and bolt back door.

7. Pull out slide of adapter and see that white spot on the envelope appears through pane of yellow celluloid. Clip slide on to back of adapter.

8. Press trigger, and

9. Push in slide.

10. Remove envelope with point of pencil, or finger, and immediately change the plate, taking care to place exposed plate in right hand satchel.

After Reconnaissance :—

Release tension with point of pencil on spring near tension winder.

WIRELESS NOTES FOR OBSERVERS.

Ground Test.—Procedure before a flight. Test the voltage of the accumulator battery to be used by means of a voltmeter, this is in some cases fitted on the transmitter. The maximum voltage permissible is 10 volts on a Sterling transmitter. It is not advisable to use less than six volts. Each accumulator cell should give a reading of two volts, so that the minimum number to be used is three. The maximum number is five cells. These cells are generally placed in suitable wooden containers.

Method of Testing the Voltage.—Connect the voltmeter by means of short wires to the terminals of the accumulator and read the voltage directly on the scale. Care must be taken that the positive pole terminal of the accumulator battery is connected to the positive terminal of the voltmeter. The positive terminal is usually marked + (plus)

and the negative — (minus). In the case of the accumulator, if there is no such indication, it is very easy to find the positive pole terminal; all the positive poles of accumulator cells are generally painted red and the negative poles black. Should there be no indication whatever, just connect the battery up to the terminals of the voltmeter, and if the needle tends to move towards the left, that is, in the opposite direction to the scale reading, the leads should be reversed. Under no circumstances should the accumulator battery be used when the voltage per cell has fallen to 1.8, so that the total voltage for a three accumulator cell battery should not be less than:—

$$1.8 \times 3 = 5.4 \text{ volts}$$

and for a five cell battery:—

$$1.8 \times 5 = 9 \text{ volts.}$$

If the accumulator battery is properly charged it should not be tampered with.

Be very careful to avoid short-circuiting the terminals of the individual cells or the battery. There are many ways of doing so. If water or dirt is allowed to accumulate on the top of the cell, the cell will very quickly become useless.

Wire, tools, knives or any other metal object placed between the terminals will quickly destroy it.

The accumulator battery should be placed in a position where it will not move during a flight. Also see that there is no undue strain on the wire leads between the battery and the transmitter.

The Sterling Transmitter.—Place the transmitter in the plane in a position convenient for use. Arrangements have probably been made for the accommodation of the set.

Connect the accumulator battery to the terminals marked "Battery" on the transmitter, or to the safety plug, if fitted.

Remove the ebonite cover at the lower end of the transmitter and over the trembler adjustment, depress the key on top and the trembler should at once begin to vibrate.

Should it fail to do so, it is probably due to the platinum contact on the trembler spring sticking to the armature contact. The platinum contacts of the trembler make and break soon become pitted, uneven and dirty in work, sparking at the contacts causes them to stick and to vibrate unevenly. These contacts should be trued up with a dead smooth file. The battery leads should be changed over periodically so as to pass the current in the opposite direction across the contacts. The adjustment of the trembler make and break is very important. Adjust the trembler by means of the adjustment screw until you obtain a good and even vibration with the minimum of sparking consistent with a good spark at the spark gap. When the correct adjustment has been made the lock nut should be very tightly secured. Now see that the wire leading from the frame of the engine is well secured there and making good metallic contact, and that it is well secured all along.

Connect the terminal at its other end to the terminal marked "Earth" on the transmitter. Now see that the lead from the "Fair

lead " is secure and that it is securely clamped to the terminal on the fair lead, the terminal on the other end of the lead should be connected to the terminal marked " Aerial " on the transmitter.

Great care should be taken that no part of the aerial circuit is in a position where it can spark to the frame, the wire stays, the wooden struts or any other part of the plane. Also see that any part of the circuit, where bare, is not likely to touch any part of the pilot or the observer, or any part of the plane.

The more powerful the set the greater must be the precautions against leakage from any part of the circuits to the machine. This leakage is most likely to occur in damp weather or when flying in clouds. Now see that the aerial drum is securely fixed on the machine, usually on the outside of the fuselage, and see that the brake is not slack and that it is holding the aerial, when wound up, in position. See that the weight is securely attached to the end of the aerial wire. Next release the tension on the brake of the aerial drum by releasing the tension on the steel spring and run out the whole of the aerial to a mast, tree, or other convenient point, and secure it there by means of an insulator or a piece of dry rope. Examine the aerial for signs of wear or fraying, also see that the aerial wire itself is making contact with the fair lead. See that the cord attached to the aerial drum and connected to the aerial wire is of the correct length, it should allow the aerial wire to make good contact with the fair lead but should not allow much of the aerial wire to be above it. A shock absorber, consisting of a large number of rubber bands, and braided, is frequently fixed between the drum and the cord. Now depress the key and adjust the length of the spark gap, commencing at the minimum, until a good, even, fat and white spark is obtained; to get best results it may be necessary to slightly alter the adjustment at the trembler make and break. The spark gap electrodes should be kept very clean and exactly parallel. To tune the sterling transmitter, place the aerial plug so as to include the whole of the tuning helix in the aerial circuit, move the closed circuit clip until the highest reading is obtained in the aerial ammeter, then move the aerial clip or plug until the reading just begins to drop, now see if any adjustment of the closed circuit clip will increase the reading in the ammeter. You may obtain further increase by placing the aerial clip in such a position as to cut out more turns of the tuning helix in the aerial circuit, then tune in with the closed circuit clip until maximum reading is obtained. When this test has been carried out successfully, wind up the aerial and hook the steel spring of the brake up, place the ebonite cover back over the trembler adjustment and secure it firmly. You are now ready for a flight.

Wireless during a Flight.—The aerial wire is generally about 150 to 250 feet in length, so you should never attempt to let it down until you are well above that height, also make allowances for trees, buildings and other objects.

When up a sufficient height, say 500 or 600 feet, let down the aerial and insert the safety plug. Do not allow it to run out too fast, this is the most frequent cause of the wire breaking in the air or of tangling.

If the wire becomes entangled it will cause difficulties and accidents when landing, as it will be impossible to wind it in completely, and the hanging wire becomes a source of danger. It may become entangled in trees and so might bring down the plane. In such a case it would be advisable to cut away the aerial. The best method of letting out the aerial is to slowly release the tension on the brake and letting the aerial run out smoothly and gradually, at the same time steadying the drum with the other hand. Let out the whole of the aerial, the rope and the shock absorber.

For best results a final adjustment of the aerial tuning may be made in the air, but it is not advisable to attempt to make other adjustments during a flight.

Before sending any message, send the letter V three or four times and also your call letters. This is to give the operator on the ground an opportunity to tune his receiver so as to get best results, and the sending of the call letters is advisable so that the ground operator may keep in touch with you and not take signals from another plane working within range, whose messages are intended for a different battery. Before coming down reel the aerial drum right up and pull out the safety plug. After landing see that the accumulator is removed for testing and if necessary for recharging.

General Notes.—Never attempt stunts on an aeroplane fitted with wireless. Do not sacrifice clearness of signals for the sake of extra speed. Always test the spark before leaving the ground. (Unless a ground test is carried out.) Remember that the strain on an operator listening intently for your signals is great. The signals are never very strong and they vary, also he has to distinguish between your signals and other wireless sets working within range. A complete understanding between the pilot or observer and the ground wireless operator is necessary to secure the best results. Always ask the wireless officer for assistance or advice when in difficulties. A ground test should be made sometimes at night with the aerial out, to observe for any sparking. All parts of the set, and especially the bare copper helix, must be kept clean. The fair lead must be kept free from oil and mud or dirt, and good contact with the aerial ensured under all conditions in the air. If the aerial makes bad contact, or touches any part of the machine, intermittent and weak signals will result. The cord between the drum and the aerial may become loose or worn, or it may stretch or become damp, this should be seen to. Great care should be taken that all screws and lock nuts are tightly secured before every flight, as the vibration is likely to shake them loose.

FLIGHT AND STABILITY.

The action of driving a plane forward forces air down, and the vertical reaction so produced is called lift. But lift is mainly due to suction above the plane. The use of the engine is to overcome the resistance through the air which is known as drift. There is also

skin friction to account for, but in a modern machine this has been very much reduced. There are two drifts, active and passive. Active is the resistance caused by the planes themselves, passive is caused by all the other parts of the aeroplane. Drift is in proportion to the square of the speed. The efficiency of a plane is generally expressed as lift drift ratio, that is the proportion of lift to drift. A flat surface is naturally stable. The centre of pressure is the balancing point of all lifting forces, and it must coincide with the centre of gravity or a vertical line drawn through it. In most modern machines, *e.g.*, B.E. 2.C., the centre of gravity is slightly ahead of the centre of pressure to cause the machine to assume a natural gliding angle when the engine is switched off. With a flat plane, as the angle of incidence decreases the centre of pressure is gradually moved forward; flat planes, however, give bad lift drift ratio, and curved planes the opposite. In curved planes as the angle of incidence decreases from 90 deg. down to 30 deg. the centre of pressure moves forward; from 30 deg. to 15 deg., it rushes forward, but below 15 deg. (the range for aeroplanes work) it moves backward.

NATURAL STABILITY.

Natural stability is that in which when an object is moved out of its normal position it tends to return again. *Natural instability* is that in which when an object is moved out of its natural position it does not tend to return but goes further.

Neutral stability is when an object is moved out of its normal position it neither tends to return nor go further. A propeller is merely a whirling plane and the resultant action in the direction of the axis of propeller is called thrust. To make a machine fly horizontally, thrust must be equal to drift, at the speed necessary for the planes to secure sufficient reaction from the air to lift the weight. To make it climb, a margin of power which is called margin of lift is necessary. This is expressed in feet (vertical) per minute. The lift is also increased when aeroplane climbs, because the propeller slightly pulls the machine upwards. Longitudinal stability is maintained by setting the fixed tail plane at a smaller angle of incidence in effect than the main plane and thereby making a dihedral angle with main plane.

Directional stability depends on keel surface which must have main effect behind turning axis of machine like the action of weather cock.

Lateral stability is obtained by means of a dihedral angle between the main planes. Also the keel surface should be roughly the same above and below the lateral turning centre. Lateral control is maintained by warp or ailerons. Longitudinal control is effected by the elevator. Maximum angle of incidence is the greatest angle of incidence at which the aeroplane can still maintain horizontal flight. Optimum angle of incidence is that angle of incidence at which lift drift ratio is best. Best angle for climbing is about half way between maximum angle and optimum angle.

MAGNETO.

Electricity exists statically in all bodies and substances showing no indication of its presence. Before it can be used it must be made to flow in the form of a current of electricity. This current has the power to produce heat, light and motive power, provided that the correct apparatus is used in each case. Electric current can be produced by mechanical means or chemical action. Both methods are used but for different work. Batteries, both storage and primary, give steady current for intermittent work such as bells, telegraph and 'phone. The dynamo gives strong currents but is bulky and has to have something to drive it.

A magnet is a piece of steel treated so that it attracts steel and iron.

If a bar magnet is suspended on a string it will assume a position with one end pointing to the north and the other to the south. This is due to the lines of force passing round the earth. If two bar magnets are put together it will be found that their unlike poles attract and their like poles repel each other. If lines of magnetic force cut a portion of an electric circuit, that is a circuit through which an electric current can flow, a current of electricity is forced through the circuit, and this current goes on flowing so long as the "cutting" process continues and the circuit remains closed.

The magneto is an alternating current dynamo. It consists of a soft iron armature wound with two sets of wiring, one thick and with few turns (the primary) the other thin and with very many turns. On revolving the armature the lines of force are cut with varying intensity and currents are made to flow in the windings varying from zero, when the coil is at right angles to the lines of force, to its maximum, when the coil is being cut by the maximum number of lines of force. Then the current begins to decrease in value till the armature has completed the half revolution. In the next half revolution the current flows in the opposite direction and varies in the same manner.

When the second coil is wound round the first primary coil but insulated from it, the act of making a current flow through the first (or primary) coil by revolving the armature creates a magnetic field round each turn of the coil and round the second coil also.

If the primary circuit were closed always, the magnetic field surrounding its coils would be of fixed intensity, therefore, the effect produced on the secondary would be NIL. The contact breaker is used to break the primary circuit when the field is at its maximum in the primary, thus causing a collapse of the magnetic field surrounding its turns. In collapsing the lines of force contract cutting the secondary windings. This sudden cutting of the large number of wires in the secondary circuit causes a rush of current through its windings, and, owing to the high voltage, it is able to cross the spark gap, and ignite the mixture in the cylinder. The condenser is connected across the contact breaker and absorbs any backlash in the current when the circuit is broken.

Insulators are steatite, rubber, shellac, silk, porcelain, vulcanite, &c.

The spark gap is a safety device to prevent strain of armature.

RENAULT MAGNETO.

Renault magneto is of sleeve type, that is to say, the armature is fixed and a sleeve revolves round it, thus giving current at every 90 deg.

There is an electrical connection between the primary and secondary windings. One end of primary is earthed to armature, the other goes to contact breaker. One end of the secondary is earthed through primary. The other goes through insulated tube in armature spindle to collector, where is safety gap, from collector connection to centre of distributor, across distributor to plugs.

Switch is in primary circuit. Primary is on closed circuit until contact is broken. The magnets are a special grade of steel. Pole pieces are soft iron and must make good mechanical contact with magnets. Armature is made of slips of steel in laminations.

ENGINES.

GNOME.

Gnome Materials.—Nickel steel, cylinders, crank case, conn. rods, tappet, tappet rods, cambox, thrust box, nose plate, exhaust valves. Cast-iron pistons, packing and wipe rings and valve guides. Phosphor bronze big end bushes, gudgeon pin bushes, cam sleeve bush, tappet guides, nose plate plug. Brass obturator rings. Hardened steel wrist pins and gudgeon pins, cam rollers, cams. Silver steel inlet valves. Forged steel exhaust valve seating and crosshead.

Oil.—Oil pump is two-cycle reciprocating, actuated by cams and springs and fed by gravity. Cams drive valve plungers down closing discharge and opening inlet. Then springs draw pump plungers up drawing oil through inlet up into pump cylinders. Then springs drive valve plungers up closing inlet and opening discharge. Cams then drive pump plungers down, forcing oil out through discharge to B and C connections.

C Supply.—Largest. From pump through copper pipe to crankshaft through tube in shaft, some goes into thrust box by a branch, oils thrust ball races and overflows from there to holes in bottom of thrust box, then runs through holes drilled in base of cylinders oiling them and pistons, the remainder passes under branch to hole in crankshaft web to corresponding holes in small end of crankshaft pin, through ditto pin down other web and out under cams, scattered over cams, cambox, and overflows through holes to crankcase and combines with overflow from thrust box, and oils cylinders and pistons. On C supply is by-pass to pulsator.

B Supply.—From pump to B on crankshaft, through copper tube to hole in crankshaft to corresponding groove in small end to annular chamber, passing out of holes in crank journal, some oils big end ball

ances, remainder passes through nipples in master conn. rod, oiling big end pins, then oil is thrown by centrifugal force up conn. rods to small ends, oiling them, and then valves and sides of pistons by holes in piston walls.

Gnome Timing.—Face engine, disconnect No. 5 tappet, place No. 3 cylinder horizontal to right which gives No. 1 correct position for closing exhaust, which is 18 deg. left of top centre, turn cam sleeve anticlockwise till cam takes up on No. 1 roller, mesh planet gear wheels, using spokes in holes provided. If correct, turn No. 1 cylinder to 65 deg. before bottom on power stroke, that is over one revolution left, No. 5 will then be horizontal, test if correct, adjust other tappet rods.

Ignition.—Place No. 1 26 degrees before top of compression stroke, No. 4 is then vertically down, turn magneto clockwise until points are about to break, mesh up and test.

Clearances.—Piston, six thousandths inch, packing ring, 3 mm. obturator ring and wipe ring, 1 mm. exhaust tappet and plug points, $\frac{1}{2}$ mm. contact breaker, 4 mm. inlet springs, 50 h.p. 4 lbs. 7 oz. 3 mm. lift. Exhaust valve lift 8 mm., do. 70 and 80 h.p. 10 lbs. 5 oz. 4 mm. lift. Exhaust valve lift 8 mm. Consumption 50 h.p. oil $\frac{3}{4}$ gallon per hour, petrol 5 to 5 $\frac{1}{2}$ gallons per hour, 80 h.p. Oil, 1 $\frac{1}{4}$ to 1 $\frac{1}{2}$ gallons per hour, and 6 to 7 gallons petrol per hour. All Gnomes roughly consume about 9 $\frac{1}{2}$ oz. petrol per h.p. per hour. Pump gearing, 7 to 4. Jets, 50 h.p. 2.2 to 2.4, 70 h.p. 2.6 to 2.9, 80 h.p. 2.4 to 2.6. Bore and stroke, 50 h.p. 110 by 120 mm.; 70 h.p. 130 by 120; 80 h.p. 124 by 140.

Valve Setting.—Fires 26 deg. before top, exhaust closes 13 deg. past top, open 65 deg. before bottom. Order of firing 1, 3, 5, 7, 2, 4, 6.

TABLE OF PULSATIONS.

50	beats	in	43	seconds	=	1,000	r.p.m.
"	"	"	41	"	=	1,050	"
"	"	"	39	"	=	1,100	"
"	"	"	37	"	=	1,150	"

THE BEARDMORE ENGINE.

This engine is a duplicate of the Austro-Daimler, differing in very few details, but identical with it in the main construction and design.

Its horse-power is 120 h.p. with a bore of 130 mm., and stroke 175 mm.

It is a six (6) cylinder, vertical, water-cooled engine, with a mean weight of 630 lbs., about 5.25 lbs. per h.p. This compares favourably in weight with other engines excepting rotary.

Its petrol consumption per hour is about 9 gallons.

The materials used in the construction are as follows:—

Crank case	...	...	Aluminium alloy.
Water pump	...	...	do.
Oil pump	...	...	do.
The two carburetters	...	...	do.
Cylinders	...	...	Cast iron, steel base.
Pistons	...	...	Steel.
Piston rings	...	...	Cast iron.
Water jacket	...	...	Copper.

The crankshaft is set in six pairs of throws, and held in position by seven main bearings (white metal), while the camshaft runs in 4 phosphor bronze bearings off the crankshaft, using an intermediate wheel.

Both inlet and exhaust valves are operated by one tappet rod with a "Bell crank lever" attachment which, operated by the inlet cam, pulls down the tappet rod and opens the inlet valve. The exhaust cam operates directly upon the tappet rod and acts upon the exhaust valve.

The water pump is centrifugal and is attached under the rear end of base of crankcase, and is run off the crankshaft.

The water is pumped directly through a short pipe into base of water jackets of cylinders, and after circling the cylinders leaves at the top returning to radiator through an overhead return pipe. The maximum temperature should not exceed 180° Fahrenheit.

The lubrication is partly by pressure, and partly by splash. The pressure feed comes directly from pump in six leads, two of these leads lubricate the cylinder walls, and the small ends. The other four leads are responsible for lubricating the seven main bearings and the thrust parts.

The remainder of the lubrication is by splash, that is to say, the oil in the sump is caught by the big ends and is thrown upon the parts needing the oil. These parts so lubricated are the big ends, camshaft, camshaft bearings.

The sump of crankcase is divided into six compartments, and contains, when erected, four pints of oil. This oil is used *only* for "Splash." Those parts (already enumerated) oiled by pressure from the pump receive the oil from an oil tank through the pump.

Oil consumption $3\frac{1}{2}$ pints per hour.

Oil to be changed in sump after 12 hours' running.

The thrust is situated in a steel housing in the front extension of crankcase. It is a double thrust, and can be used as a tractor, or pusher, without alteration.

It consists of a fixed steel washer, thrust ball races, and steel washers.

The action of the thrust is as follows:—

Pusher.—The thrust is taken on the *inside* of the fixed steel washer, on to thrust ball race, on to steel washer, and finally on to the housing.

For a Tractor.—The same action, only the thrust is taken on the *outside* of the fixed steel washer, and on to thrust ball race, steel washer and to housing.

Ignition.—The ignition system is effected by two magnetos, two sets of wiring and two plugs for each cylinder, thus you get two sparks simultaneously, ensuring a speedy and effective expansion of the mixture. It is of the utmost importance, when timing the engine, to have both magnetos synchronised, that is to say, the points on the "Make and Break" of both magnetos to break at precisely the same moment, otherwise one magneto becomes non-effective.

Carburation.—Carburation is effected by two carburetters, each serving three cylinders, and both operated by one control lever. They

are the Beardmore type. They have a water jacket connected from the return pipe to radiator, to heat the mixing chamber. Other features are the annular floats, which ensure an even supply of petrol to the jet, in the centre of the float chamber, at whatever angle the engine may be, and an extra air inlet port which comes into use as the engine is opened out.

Connecting rods.—Big ends have bearings of white metal, while the small ends are fitted with a phosphor bronze lish. Big end side play not to exceed 0.2 mm.

Pistons.—Are steel with three piston rings of cast iron. Pistons also have three oil grooves, two small and one large. The larger groove is to convey oil to small end bush, through gudgeon pin. Great care has to be used in handling the pistons when erecting engine, also when driving in gudgeon pin, as they are liable to get distorted.

Cylinders.—Are cast iron with steel base. The steel base is for strength, and is screwed and sweated on, otherwise when tightening down cylinders to crankcase the nuts would break off the lugs if tightened too much.

Water Jackets.—Are of copper, electrically deposited on cylinders, by special process of manufacturers.

Valves.—Both valves are situated in the head of the cylinders, and are operated by a rocker arm and a leaf spring of 46 lbs. lifting strength. The lift of the inlet and exhaust valves is 7.5 mm.

Timing the Valves.—If the timing gears are not marked, then the following method for timing the valves is to be observed:—

1st. Turn crankshaft anti-clockwise until piston of No. 1 cylinder is 0.5 mm. after T.D.C.

2nd. Turn camshaft same direction until exhaust valve has just closed. Then put intermediate timing wheel in position.

Check remainder of cylinders for correctness.

The clearance allowed for expansion for both valves is 0.7 mm. The camshaft runs half the speed of the crankshaft. Engine should do 1,200 revolutions per minute.

Ignition Timing.—Turn crankshaft until piston of No. 1 cylinder is T.D.C. on compression stroke, then turn back 12 mm. down stroke, adjust your magnetos with points just breaking (full advance) and place in position.

Cycle of Operations.—The cycle of operations are four:—

Induction stroke.

Compression stroke.

Power stroke.

Exhaust stroke.

Inlet valve opens 8-10 mm. A.T.C.

" " closes 10-12 mm. A.B.C.

Exhaust valve opens 18-20 mm. B.B.C.

" " closes T.D.C.

Propeller is run off crankshaft.

To start Engine.—Throttle down, mechanic will close air ports, have switch off. Petrol on. Mechanic will turn propeller several

times to fill cylinders with mixture. He will then *stand clear*. You will then switch on, and turn handle of starting magneto sharply and engine will start.

N.B.—Never attempt, or allow anyone, to try and start engine by swinging the propeller.

RENAULT.

Materials.—Cast steel bridges and gear wheels. Aluminium alloy crankcase. Cast iron cylinders, ditto heads, piston rings. Pressed steel piston, silver steel camshaft. Phosphor bronze bearing shells, cam bushes, tappet guides, and small ends. White metal main bearings.

Clearances.—Piston ring gap 32 or 25 thousandths; clearance on top of piston .016; on bottom .018; oil pressure 3 to 5 pounds. Pump gearing 7-4; inlet tappet clearance .025, exhaust do. clearance .04. Jet sizes 1.6 to 1.75 mm. Oil, vacuum BB. or B. Capacity of sump in 1913 model is 3 gallons. Clearance of platinum and plug points is .5 mm. Magneto speed is same as crankshaft. *Petrol* 7½ to 8 gallons per hour. *Oil* 5 pints per hour, or 7 ounces per h.p. per hour.

Valve Timing.—Exhaust closes dead top, inlet opens 4 mm. past top, inlet closes 18 to 20 mm. past bottom centre. Exhaust opens 18 to 20 before bottom centre ignition 11 mm. before top. Order of firing 1, 5, 3, 7, 4, 8, 2, 6. Bore 96, stroke 120 mm. Compression 80 lbs. to square inch.

Oil is taken by pump and forced up passage in sump on to outside through inside of strainer, from there filling oil way in crankcase, leading to three main bearings, gear wheels and thrust bearing into main bearings journal, up through webs to crank journals, oiling big ends from there, after that all splash. Also there is pass to thrust box. In banjo type of crankshaft, oilways in outside of bearings are cut to edge allowing oil to flow into banjo and oiling crank journals by centrifugal force. Rockers and pins are oiled by hand daily. Sump holds to top of test hole 3½ gallons.

Thrust in pusher machine is taken on inside of flange against steel washer, thrust ball race, steel washer and radial ball race, then on to crankcase. In tractor, thrust is taken on outside of flange, against steel washer, thrust ball race, distance piece and radial ball race, thence to end plate. When indicator shows 1800, cable does 450, 4-1 pump spindle does 520 = 7-1, indicator to cable 8-7.

100 H.P. MONOSOUPAPE.

General Description.—The Monosoupape as its name implies has only one valve, this being the mechanically operated exhaust valve in the cylinder head. The chief features of this engine as compared with those of the ordinary Gnome are:—

- (1) Absence of inlet valves.
- (2) Solid piston heads.
- (3) No carburetter.
- (4) Non-explosive mixture in the crankcase.

The crankcase is made in two halves (steel castings) fastened together by nine bolts. The cylinders are located by keys, and held by a recess turned in the bottom exactly in the same manner as an ordinary Gnome. The mixture in the crankcase is admitted into the cylinders by the pistons uncovering on their downward stroke a series of holes drilled near the bottom of cylinders. The weight of the exhaust valve is adjusted so that the centrifugal effect when rotating is equal to the tappet rod and lever, avoiding the use of balance weights as in the case of a Gnome. The control gear which was fitted with the early types of this engine has now been superseded by a design of cambox exactly similar in general design to that of an ordinary Gnome. In engines where this control gear is fitted a locking piece is fitted to prevent the gear being used. An oil pump is fitted similar in design to that of a Gnome pump, but the deliveries from each of the two pipes are equal allowing either pipe to be connected to the unions on crankshaft. It will be noted in the lubrication of the gudgeon pins we employ pipes to carry the oil instead of relying on centrifugal force as in the case of a Gnome. This is done on account of the free petrol which is present in the crankcase. It is essential in this engine to fit a wrist pin in the master rod to connect up the lubricating system.

The engine can be used for "Tractor" or "Pusher" type machines. In a "Tractor" the nose plate is open and the rear end closed, but in a "Pusher" the nose plate is plugged up and the large end of crankshaft is opened, allowing air to enter the crankcase. Finally the rotary principle of the Monosoupape is exactly the same as that of an ordinary Gnome.

List of Clearances, Valve Settings, &c. :—

H.P.	...	...	...	...	100.
Speed	...	...	...	...	1200 r.p.m.
Bore	...	...	...	...	110 mm.
Stroke	...	...	...	...	150 mm.
Exhaust valve closes	...	...	...	...	60° before B.D.C.
" " opens	...	...	...	...	90° past T.D.C.
" " tappet clearance	...	...	...	...	.5 to 1 mm.
Contact point gap	...	...	...	...	.5 mm.
Piston clearance in cylinder	...	...	...	...	5/1000".
Obturator ring gap	...	...	...	...	.8 to 1 mm.
Packing ring gap	...	...	...	...	2 mm.
Wipe ring	...	...	...	...	20/1000".
Consumption of oil	...	...	...	...	2 gallons per hour.
" " petrol	...	...	...	...	9-10 gallons per hour.
Weight	...	...	...	...	800 lbs.
Order of firing	...	...	...	...	1, 3, 5, 7, 9, 2, 4, 6, 8.

The cylinders are numbered 1 to 9 consecutively, in a clockwise direction when facing propeller.

The engine revolves anticlockwise when facing propeller.

The type of magneto used is the Bosch type D.A.

Diameter of exhaust valve .55 mm.

Lift of exhaust valve 9 mm.

Petrol Supply.—The petrol is pressure fed from the tank to a copper pipe running inside the crankshaft. The petrol flows along this tube through the centre of large crank web, hollow crank pin, and down the centre of small crank web out of the petrol jet, which is situated in the bore of the small end just underneath the crank web. A slight amount of air enters the crankcase from the front of the engine, and assists the spray in vaporizing the petrol. This is further assisted by the connecting rods, and is thrown centrifugally into the recesses in the base of the cylinders ready to be drawn into the cylinders on the induction stroke.

Cycle of Operations.—The engine is worked on the "Otto Cycle" principle, i.e., four strokes to one cycle of the engine. Starting with the cylinder on top vertical position and exhaust valve open, the cylinder goes forward until a point of 60° before B.D.C. is reached where exhaust valve closes. During this period pure air has been drawn into the cylinder through the exhaust valve. The cylinder then goes forward to a point 20° before B.D.C. creating a partial vacuum, and at this point the ports in the cylinder walls become uncovered by the piston allowing the rich gas from the crankcase to enter the cylinder. This continues until a point 20° beyond B.D.C. is reached, where these ports again become covered by piston and the cylinder goes forward on compression stroke to T.D.C., ignition occurring 15-20° before T.D.C. Continuing on the second revolution of the cycle the cylinder goes forward until a point 90° past T.D.C. is reached where the exhaust valve opens and continues open for the exhaust stroke round to T.D.C., where the cycle of operations is again commenced.

NOTE.—It has been found that a series of small cylindrical holes is better than a series of slots as shown in sketch in small book, page 5.

Lengths of Strokes :—

Power stroke	...	...	...	00—900	900
Exhaust stroke	...	...	...	900—3600	2700
Admission of pure air	...	...	...	00—1200	1200
Partial vacuum	...	...	...	1200—1600	400
Admission of rich gases...	...	...	...	1600—2000	400
Compression of stroke	...	...	...	2000—3600	1600

Valve Timing.—Timing of No. 1 cylinder :—Turn the cylinder round until it is 60° before B.D.C. (This will bring No. 4 cylinder vertically upwards.) Turn the cam pack anticlockwise until No. 1 exhaust tappet is just about to be lifted by the cam, then mesh the planet gears. Adjust all the tappet clearances and check the valve closing position.

Ignition Timing.—Turn the engine until No. 1 cylinder is 20° before T.D.C. on compression stroke. Set the magneto so that the platinum points are just breaking and mesh magneto driving gear. Wire distributor to plugs correctly and the engine is then fully timed.

Lubrication.—This is dealt with in quite a capable manner on pages 25 and 26 of small book.

Materials :—**Various Kinds of Steel :—**

Cylinders.	Tappet roller.
Crankshaft.	Cams.
Thrust box.	Nose plate.
Cam box.	Cam box cover.
Exhaust valve.	Connecting rods.
" " cage.	Gudgeon pin.
Rocking lever.	Wrist pins.
Tappet rod.	All gears.
Tappet.	Crankcase bolts.

Cast Iron :—

Exhaust valve guides.	Piston packing ring.
Pistons.	Wipe ring.

Phosphor Bronze :—

Wrist pin bushes.	Cam sleeve bush.
Gudgeon pin bushes.	Exhaust tappet guides.
Nose plate plugs.	

Special Bronze Alloy.—Obturator ring.

Steel Castings.—Crankcase.

Improvements on the later type.—There are seven more radiating fins on new French engine. The sparking plugs are placed in a better position for wind resistance, *i.e.*, horizontal.

A spring washer is placed behind ball race on small end of crankshaft to prevent ball race stopping in master-rod when stripping.

A spiral spring is now fitted on exhaust valve.

The control gear has been abolished.

The jet is horizontal instead of vertical.

List of purposes the Crankshaft serves :—

- (1) It is the principal means of attaching the engine to the aeroplane.
- (2) It conveys oil to the working parts.
- (3) It conveys petrol to the crankcase.
- (4) It provides a fixed point for each cylinder to exert itself on in turning the engine.
- (5) The small end forms a pivot around which the cam-sleeve turns.

R.A.F. ENGINE.

General Description.—This engine is similar in design to a French Renault, but has several improvements, the chief of these being the mounting of the crankshaft and camshaft on ball and roller bearings. The crankshaft is supported on four roller bearings and one ball bearing, the object of fitting the ball race on crankshaft being to form a definite locating point. The camshaft is supported on three ball bearings and one phosphor bronze journal in the centre. It will thus be easily seen that friction on these two shafts has been almost eliminated. The cylinders are cast in one piece (*i.e.*, cylinder body and combustion head complete), thus eliminating a joint as we have

on a Renault cylinder. The carburetter on this engine is a double Claudel Hobson R.A.F. type, and has two throttles, and two air flaps, but only one float. The controls are combined, thus making the controlling of carburetter exactly like a single Claudel Hobson. The gases from the two throttle chambers pass up through cored passages in the flywheel cover and thence through copper induction pipes to the cylinders. This pipe is built up in sections, each section being connected to the next by a rubber jointpiece. This way affords greater ease in fixing pipe in position and also it is more reliable owing to the fact that each side of the engine has its separate induction pipe. The ignition on this engine is effected by two magnetos, placed on a bracket on the flywheel cover, which are driven by a spur gear fixed on the end of the crankshaft. The distributors revolve in the same direction, the magnetos themselves firing alternately. Two breathers are placed at the propeller end of sump to relieve the back pressure in the crankcase. The exits of same are so placed so that if by any chance oil is blown through it is blown on to the exhaust tappet rockers and springs. An air pump is fitted on the top of the crankcase to provide a pressure to the petrol storage tank. This is worked by a cam on the camshaft. An oil gauge or ball float indicator is fitted to the sump to register the amount of oil contained.

List of Clearances, Valve Settings, &c. :—

Exhaust valve closes—1 mm. past T.D.C. or 3 mm. past T.D.C.

Exhaust valve opens—22 mm. before B.D.C. or 23 mm. before B.D.C.

Inlet valve opens— $1\frac{1}{2}$ mm. past T.D.C. or 4 mm. past T.D.C.

Inlet valve closes—16 mm. past B.D.C. or 18 mm. past B.D.C.

Ignition 12 mm. before T.D.C. on compression stroke or 15 mm. before T.D.C. on compression stroke.

Exhaust valve tappet clearance— $\cdot006''$.

Inlet valve tappet clearance— $\cdot006''$.

Bore of cylinder—100 mm.

Stroke of piston—140 mm.

H.P. (minimum accepted)—92 or 93.

Speed—1,600 or 1,800 revolutions per minute.

Big end side clearance— $\cdot006''$ to $\cdot008''$.

Small end side clearance—2 to 3 mm.

Piston clearance— $\cdot006''$ to $\cdot008''$.

Piston ring gap— $\cdot03''$.

Piston ring side clearance— $\cdot004''$.

Height of taper cone plug above exhaust valve spring cover must be between 2 to 3 mm. when new.

Consumption of oil—4 to 5 pints per hour.

Consumption of petrol—8 to 9 gallons per hour.

Weight (unladen)—440 lbs. approximately.

Order of firing—1, 5, 3, 7, 4, 8, 2, 6.

Oil should be drained from sump and sump cleaned after 20 hours' flying.

The valves and pistons should be examined, cleaned and reground if necessary after 50 hours' flying.

The class of oil used is Sternol, or a mixture of Vacuum A and B in equal quantities.

The sump will hold 25 pints of oil for normal flights, but a further five pints may be added if a long flight is contemplated.

The types of magneto used are the Bosch DU4, ZU4 or ZF4. When ZF4 is used a packing piece of 5 mm. is required underneath the magneto straps. On new engine one magneto B.T.H. Type A8 will be fitted.

Dismantling :—

- | | |
|--|--|
| 1. Carburetter. | 11. Tappet guides complete and air pump. |
| 2. Top of engine cowl. | 12. Magnetos. |
| 3. Exhaust branches. | 13. Flywheel cover. |
| 4. High tension wires from magnetos and plugs. | 14. Front cover. |
| 5. Induction pipes with wires and supports. | 15. Sump. |
| 6. Breathers. | 16. Reverse engine in stand. |
| 7. Cylinder holding down nuts. | 17. Big end caps and connecting rods. |
| 8. Engine cowl. | 18. Oil pipes and main bearing caps. |
| 9. Cylinders with valves complete. | 19. Crankshaft. |
| 10. Pistons. | 20. Camshaft. |

Materials :—

Cast Iron :—

- | | |
|--------------------|---------------|
| Inlet valve guide. | Piston rings. |
| Pistons. | Cylinders. |

Various Kinds of Steel :—

- | | |
|------------------------|----------------------|
| Crankshaft. | Exhaust valve. |
| Camshaft (complete), | Inlet " |
| Connecting rods. | Springs. |
| Main bearing caps. | Tappet rocker. |
| Timing gears. | " rod. |
| Magneto driving gears. | Tappets. |
| Oil banjoes. | Exhaust valve guide. |
| Gudgeon pins. | Several minor parts. |
| Cylinder stay bolts. | |

Phosphor Bronze :—

- | | |
|-----------------------|-----------------------------|
| Exhaust tappet guide. | Induction valve pocket nut. |
| Inlet " " | Camshaft bush. |
| Air pump body. | Plugs. |

Aluminium Alloy :—

- | | |
|--------------|------------------|
| Sump. | Flywheel cover. |
| Crankcase. | Magneto bracket. |
| Front cover. | |

Timing (Valve).—Get No. 1 piston 1 mm. past T.D.C., unmesh timing gears and call this the end of exhaust stroke. Set the clear-

ance on No. 1 exhaust tappet to 12/1000ths of an inch and turn the camshaft in correct way of rotation until the valve has opened and just closed. At this point remesh timing gears. Set the remaining valve tappet clearances with tappets on the lowest position of cams. Check valve positions to see if they are correct.

Ignition Timing.—With No. 1 piston 12 mm. before T.D.C. on compression stroke, set No. 1 magneto so that platinum points are just about to break and mesh magneto driving gear. With No. 2 piston in position for firing set and mesh No. 2 magneto. Wire magnetos to plugs correctly and the engine is then fully timed.

N.B.—On new engines provision is made for registering the firing point by means of a series of holes drilled in flywheel, which correspond to two holes on flywheel cover.

Lubrication.—The lubrication on this engine is chiefly by splash. The flywheel which is situated at the rear of the engine is enclosed and revolves partly submerged in oil. The oil is carried round on the rim of the flywheel until it reaches the top of crankcase, where it is thrown into an oil passage that leads the oil into an oil duct running the full length of the crankcase. From this duct two pipes lead the oil to the base of the second and fourth main crankshaft bearings, where it immediately overflows into oil banjoes. These banjoes pass the oil through the crank web into the hollow crank pin and thence out of holes in same, lubricating the big ends of connecting rods. The overflow from the big ends is caught up by the crankshaft and thrown into the interior of the cylinder, thus lubricating the cylinders, pistons, gudgeon pins. The oil duct in crankcase terminates in a hole which is connected to a pipe on the front cover that leads the oil round on to the intake side of the timing gears, oiling gears and thrust races at this end. All the bearings on crankshaft, camshaft, tappets, cams, cam guides, and other internal parts are oiled by splash. The valve rockers, springs, magnetos, and other external parts are oiled by hand preparatory to a flight. A by-pass has now been fitted to regulate the supply of oil to the engine. Delivery plates can be fitted (to regulate the supply of oil) to the oil pipes leading to the second and fourth main bearings. The baffle plates in cylinder mountings have been drilled to allow a better supply of oil to cylinders. A small hole is drilled at the end of the oil duct to prevent air locks.

THE LE RHONE MOTOR, TYPE C. 80 H.P.

The Le Rhone engine is a 9-cylinder, air-cooled, petrol engine, working on the 4-stroke or Otto cycle.

The cylinders are of 105 mm. bore by 140 mm. stroke.

The normal revolutions per minute of the engine are 1,150, and at this speed the engine develops well up to its rated h.p., with a steady reading for continuous runs.

The cylinders are of steel, but to reduce frictional loss and to minimise distortion they are fitted with cast-iron liners. The liners are renewable, should they become scored or otherwise damaged. This method of construction makes it possible to dispense with the

light brass piston rings which have proved so troublesome in air-cooled rotary engines. As a consequence of the cylinders being screwed into the crankcase it is impossible, without pinning the piston rings, to determine that the piston ring gaps will not work into line, but to reduce this risk to a negligible quantity four steel piston rings of light section are fitted.

The crankshaft is stationary, and the cylinders, crankcase, &c., revolve round it in an anti-clockwise direction.

The engine revolves on ball bearings, and whilst the connecting rods are mounted in plain bearings, the big end, as a whole, revolves on ball bearings.

Throughout the engine, all parts are numbered, and to ensure correct assembling and tuning a number of the parts have distinguishing marks, which must be kept in line.

To enable the cam pack to be removed, the pins of the four lowest rockers in the crankcase must be removed.

Whenever the engine is at rest, if only for a few minutes, the sparking plugs of the two lowest cylinders must be removed, to allow the oil which will accumulate in these cylinders to drain away.

In planing down from a height, it is advisable for the pilot to keep the engine firing lightly in order to keep the sparking plugs free from oil. The combination of a mechanical inlet valve and the excellent Le Rhone carburetter makes it possible to throttle the engine down to a very low number of revolutions per minute without misfiring. This feature is most useful in running the aeroplane into position on the aerodrome, prior to, and after, a flight.

Materials :—

Steel :—

Crankshaft.	Gudgeon pins.
Cylinders (cast iron liners).	Thrush box and contents.
„ lock rings.	Cams, cam carriage, &c.
Crankcase.	False nose plate.
Connecting rods.	Nose extension.
Rockers (overhead).	Valves, guides, springs, &c.
„ (in crankcase, carrying cam rollers).	All bolts and nuts.
Piston rings.	Inlet pipe flanges.

Cast Iron :—

Cylinder liners.	Pistons.
------------------	----------

Phosphor Bronze.—Connecting rod bushes and bearings (both ends), roller bushes on rockers bearing on cams. Compression retainers on tappet guides.

Copper.—Inlet pipes, rubber packing.

Copper and Asbestos.—Joints between inlet pipe and crankcase and inlet pipe and cylinder.

Ball Bearings (Radial) :—

Main ball race.	Thrust box, back of.
Big ends (2).	Overhead rockers (18).
False nose plate (sometimes double).	Cam pack (2).

Ball Bearings (Thrust).—Thrush, double, in thrust box.

The *crankshaft* is made in two pieces, to allow the big ends of the connecting rods being mounted on ball bearings. The two pieces are joined together by two methods. One method has the crank pin end cut to a tapered cone joint with a round key to give correct register, and a nut to secure the small piece of the crankshaft on to it. The other method is similar but has a tapered cone and tapered square combined. The former one is that most in favour and gives the best result. The purposes for which the crankshaft is used are :—

Attaching the engine to the aeroplane.

Point round which the engine revolves.

Point on which the pressure of the pistons exerts its force.

Induction tube from carburetter to crankcase.

An oil lead.

To carry the propeller.

To take the thrust of the propeller.

The crankshaft, at the point where it fits into the back plate, is parallel and has two keys, one on either side, to register the shaft correctly in the back plate. The hole between the keys is for the admission of oil, and is on the upper side.

The crankshaft is held in the back plate by a threaded collar, screwed on the crankshaft behind the back plate. An additional bearing is fitted on the rear end of the crankshaft, which is also locked in position by a threaded collar on the crankshaft.

The *crankcase* is in one piece and of very light construction. On the front or timing side there is an extension of the crankcase for the purpose of carrying the valve rockers, and lower ends of the inlet pipes. The front of the crankcase is closed by the nose extension, which is practically the same diameter as the crankcase. Studs are provided, by means of which the inlet pipes and nose extension are fixed in place.

The *thrust box* is on the back of the engine, and in addition to the two radial ball races on which the engine revolves, there is a thrust race, composed of three hardened steel plates, with two rows of balls between them. The thrust race is held in position against a shoulder in the thrust box by means of a threaded collar, the latter being secured by a screw. On the rear of the thrust box is a distributor, which is keyed in position, and the toothed wheel for driving the magneto and pump.

The *cylinders* are of steel, fitted with cast-iron liners. The inlet and exhaust valves are in the cylinder head, and to grind them in, the cylinders must be removed from the engine. The single rocker for operating both valves is screwed into the cylinder head in front of and between the two valves. The cylinders are threaded at the base to about 16 threads to the inch, and a threaded collar is provided for locking the cylinders in position. In fitting new cylinders the threads must engage and run together without undue force. Cylinder threads are the ones to ease, if fit is too tight. The cylinders being threaded, and the tappet rods and inlet pipes adjustable, enables the compression space to be adjusted." In cold weather the distance from numbered shoulder on crankcase at

base of cylinder to outside of top radial fin on cylinder is 7 15-16 inches. In hot weather and for flights of long duration in cold weather the cylinders should be adjusted to eight inches. New cylinders should be smoothed inside with fine grinding paste and a piston kept especially for the purpose. All traces of grinding paste must be removed before the cylinder is used.

The *pistons* are of fine cast iron fitted with steel piston rings. Gudgeon pins must be a good fit to require tapping with a hide hammer for the last quarter of an inch. Gudgeon pins which are loose in the piston bosses will cause the skirt of the piston to break away. On the outside diameter of the piston and for some distance round the gudgeon pin hole, the piston is ground away to allow for the expansion of the piston due to the tightness of the gudgeon pin. Highly polished places on the piston must be eased off with fine emery cloth and sharp edges on the skirt of the piston ground off. New pistons must always be ground in with fine grinding paste, in a cylinder kept especially for this purpose. All traces of grinding paste must be removed from the piston before it is replaced.

The gudgeon pin is hollow and is secured in place by two bolts which pass through clearance holes in the boss and gudgeon pin, and are threaded into the piston wall behind the piston rings. In some engines an oil baffle plate is fitted inside the piston, and in these cases it is secured in place by the same bolts as secure the gudgeon pin. Spring washers are always used to secure these bolts. The pistons should always be carefully examined for cracks whenever the engine is overhauled, and close to the gudgeon pin boss should receive special attention.

A semi-circular piece is cut from the side of the skirt of the pistons to allow the pistons to pass one another at the bases of the cylinders. This clearance is placed on the trailing side or to the rear in the direction of the rotation.

The *piston rings* are of steel and four in number. They will have a gap of one millimetre, and must not fit tightly in their grooves. Should the points wear sharp they must be eased off with a fine file. The gaps in the rings to be placed on opposite sides of the piston, two gaps on each side alternating in order.

The *inlet pipes* are now of copper, with steel flanges, brazed on to the ends. An expansion joint with a rubber packing is provided in the middle of the pipe. This joint also allows of the variation of the compression space as described earlier under the heading of "Cylinders."

Copper and asbestos washers are now used to make a gas tight joint between the cylinder, inlet pipe and crankcase.

The *ball races* require continuous attention and must be examined every five hours the engine is run. The small ball races in the cam pack, and particularly in the false nose plate, require frequent renewal due to chipped balls and damaged races. It therefore follows that all ball races must receive very careful attention at all times. False nose plates will be found with both single and double ball races, and they may be fitted with two single races in place of one double one.

The *cam pack* consists of two plate form cams (the upper one for exhaust and the lower one for inlet) mounted together on a cam carriage. The cam carriage is mounted on ball bearings, and has an upturned lip which is internally toothed, and which forms one of the two gear wheels regulating the timing. The cams are cut by hand from plates of steel, and as a consequence there may be, and are, slight variations in the durations of the operations. For this reason it is advisable to check the manner in which the engine is timed whenever an engine is received, and make a note of this in the engine's log book.

Valve Timing.—In assembling the engine the valves will be timed and it only remains for the tappet rods to be adjusted. Adjust total clearance over either valve stem to 2 mm. Set tappet rod of cylinder on inlet stroke vertically downwards, then cylinder on left should have tappet rod adjusted to commence the opening of the exhaust valve. Repeat for all cylinders. Both valves are worked by a common rocker, and the latter is worked by one rod, and the latter is alternately under tension and compression, according to which valve is being operated. As there are clearances between the valves and the rocker, it follows that there is a "dead" position between the closing of the exhaust valve and the opening of the inlet valve in the cycle of operations. In this "dead" position, the clearances between the valve stems and the rocker should be checked with suitable gauges. The clearance over the inlet valve should be 1·2 millimetre, and that over the exhaust valve 0·8 millimetre. These clearances should not be exceeded but may be slightly less.

Ignition Timing.—Ignition takes place at 26° before top dead centre, on the compression stroke. This position is found by turning the engine anticlockwise until the cylinder to be timed is on the right of top dead centre, and with both valves closed, on the compression stroke. For example, number this cylinder No. 6. This will bring No. 3 cylinder about horizontal on the left. The engine should now be moved to bring the *tappet rod* of No. 3 cylinder horizontal on the left of engine. This movement will bring No. 6 cylinder into the correct position for ignition. The points on the contact breaker should just be breaking.

The *order of firing* is 1, 3, 5, 7, 9, 2, 4, 6, 8. The magneto gives two sparks for each revolution of the armature, and is geared nine revolutions to four revolutions of the engine.

The *cycle of operations* varies slightly in different engines, but an average one will be found to give :—

Induction—20° past T.D.C. to 34° past B.D.C.

Compression—34° past B.D.C. to T.D.C. (Ignition 26° before T.D.C.)

Power—T.D.C. to 38° before B.D.C.

Exhaust—38° before B.D.C. to 40° before T.D.C.

Exhaust closes at 6° past T.D.C. when engine is running.

(T.D.C. = Top dead centre; B.D.C. = Bottom dead centre.)

The *inlet and exhaust valves* are of the usual mushroom type and are in the cylinder head. No detachable seating is provided, the valves

being seated into cone shaped holes in the cylinder top. It therefore follows that the cylinders must be removed to enable the valves to be removed or ground in. The valve springs may appear weak, but it must be borne in mind that centrifugal force is a very material assistance in returning these valves to their seats. The rocker on the cylinder head operating the valves is mounted on ball bearings and rarely gives any trouble. Hand lubrication is necessary before every flight.

The *magneto* is of the usual type fitted to rotary engines, and gives two sparks for each revolution of the armature. It is geared nine revolutions to four turns of the engine, thus giving the necessary 18 sparks for the two complete cycles obtained in four turns of the engine.

Great attention must be paid to the care of the magneto on all nine cylindered rotary engines as the magneto runs at about the limit of its capacity. The bolts by which it is secured to the back plate and the driving pinion on the end of the armature shaft should be continually checked to see that they are tight up.

The *carburetter* gives no trouble whatever. The petrol is fed generally from a gravity tank through a "fine adjustment" valve to the carburetter jet. The "fine adjustment" valve is under the control of the pilot and is to control the pressure and quantity of petrol delivered from the tank to the carburetter jet. In the jet there is a tapered needle, and the latter is loosely jointed in the end of the slide which throttles the air entering the engine. As the throttle is opened or closed, so is the amount of petrol thus adjusted in proportion to the amount of air admitted to the engine. To avoid the engine being flooded with petrol, after petrol is turned on, and before the engine is started, two drain pipes are provided on the under side of the carburetter. These carry the surplus petrol to the outside of the body of the aeroplane, where it drains harmlessly away. The air supply is drawn through two aluminium pipes from either side of the aeroplane body, so that in the event of a backfire through the carburetter, the flame passes harmlessly into the air at the sides. There is a double control in the cockpit, one for the fine adjustment, and the other on the throttle. These are both provided with numbered slides, in order that the pilot may know in what position to place the levers for starting up and maximum speed. The carburetter is so constructed that it may be fixed on the end of the crankshaft in four different positions, and will suit the disposition of parts in any type of aeroplane.

Spring controlled bell crank levers are provided for taking the controls round corners, and the tension of these levers can be adjusted as desired.

The *lubrication* is exceedingly well carried out throughout the motor, and little or no trouble need be feared from this source. The whole of the oil (castor oil is used, because it is not affected by petrol gas) is taken through one lead into the crankshaft and is distributed, either by force or centrifugal action, to every part of the inside of the engine. At several points the quantity emitted is

restricted, in order that a suitable quantity may be forced on to other points.

TABLE OF PULSATIONS SHOWING IN PULSATOR GLASS.

Pulsations per minute.	Revolutions per minute.	Pulsations per minute.	Revolutions per minute.	Pulsations per minute.	Revolutions per minute.
B.	7 Cylinder.	C.	9 Cylinder.	E.	18 Cylinder
7	200	9	250	9	200
14	400	18	500	18	400
21	600	27	750	27	600
28	800	36	1,000	36	800
34	971	37	1,027	45	1,000
35	1,000	38	1,055	46	1,022
36	1,028	39	1,083	47	1,044
37	1,057	40	1,111	48	1,066
38	1,085	41	1,139	49	1,089
39	1,114	42	1,166	50	1,111
40	1,142	43	1,194	51	1,132
41	1,171	44	1,222	52	1,155
42	1,220			53	1,178
				54	1,200

110 H.P. LE RHONE.

DIFFERENCE BETWEEN 80 H.P. TYPE "C" AND 110 H.P. TYPE "J."

80 h.p. 105 by 140, 110 h.p. 112 by 170.

Petrol the same. Oil the same. Viz.:—5·5 litres of oil, 36 do., petrol. The position of the cams is at the back of the crankcase, which is covered by a cover plate, or thrust box as it is called in the 80 h.p. This plate takes the cam driving wheel, which engages the internally toothed wheel of the cam carriage. It also takes the thrust ball race, thus doing away with the longitudinal bearing and ball race of the 80 h.p. It also takes the distributor and magneto and pump driving wheel.

Where it fits into back plate crankshaft is cone shaped. Piston heads are convex on 80 h.p., concave on 110 h.p. Valves are flat in 80 h.p., convex in 110 h.p.

110 h.p. induction pipes are longer and run from side of cylinder to back of crankcase.

Nose plate of 110 h.p. is longer and houses small end ball race, so there is no false nose plate.

110 h.p. gives average revolutions of 1,200, throttled down to 800 revolutions per minute.

Assembling.—Main ball race must be flush with inside of crankcase. If protruding in crankcase, screw up locking ring that locks

thrust box. Chalk teeth which have to engage on cam carriage and driving wheel on back of thrust box.

Ball race on small end of crankshaft is secured by a nut with a left-hand thread.

Gaps on piston rings at 90 degrees to one another.

Cylinders measure from crankcase to inside of top radial fin 232 m. Gauge for setting cylinders true made of strip of steel to lie on top flat fin, long enough to rest on three cylinders. Lock centre cylinder and repeat for other cylinders.

Clearance between valve stem and rocker 2 m., distributed 8/10 m., for exhaust 1·2/10 m., for inlet.

When sure valve clearances are correct, place in position a timing plate marked off in degrees—this plate has two pins which fit the holes of the back plate at top and bottom, so that when the timing plate is in place it is reading zero at T.D.C.—by this plate you can prove timing to a degree.

Cycle of Operations :—

Induction—18-25° past T.D.C., to 30-35° past B.D.C.

Compression—30-35° past B.D.C. to T.D.C. (Ignition 26° before T.D.C.)

Power—T.D.C., to 50-45° before B.D.C.

Exhaust—50-45° before B.D.C. to 5-8° past T.D.C.

Half turn tappet rod equals 3°.

Engine to be overhauled every 30 hours it is run.

80 h.p. cyls. measure 20 c.m. from square on crankcase to inside T.R.F. pulsator glass, 1 Pulsation equals 27-77 revolutions.

CURTISS OX. 90 H.P.

NORMAL SPEED 1,200 REVOLUTIONS PER MINUTE.

Bore 4", stroke 5", normal direction anticlock.

Type.—8-cylinder "V" cylinders mounted in two rows of four cylinders at 90°, above crankshaft.

Cylinders are of cast iron, both valve seatings machined in the cylinder head.

Water jackets of a non-rusting alloy, Nomal metal, are built round sides of the cylinders, the water jackets at the cylinder head is cast with the cylinders.

The upper half of the crankcase is of aluminium, and the lower half or sump is of aluminium.

The crankshaft has four throws at 180°, and is mounted upon five white-metal bearings, all secured to the top half of the crankcase.

The connecting rods are of cast steel, bushed with phosphor bronze, faced white metal, at the big ends, and are cross-pinned to the hollow steel gudgeon pins at the little ends.

Pistons.—Are of cast iron with slightly domed heads, having three cast iron piston rings in separate grooves, above the gudgeon pin. The bearings of the steel gudgeon pins in the piston bosses are not bushed.

Camshaft is mounted on five aluminium alloy bearings, in the crankcase, vertically above the crankshaft. On the shaft there are 24 cams machined from the solid, the inlet cams being in duplicate, one on either side of the exhaust cams. One rocker support is clamped to the cylinder head by two bolts.

Exhaust valve is opened by an overhead rocker operated by a tappet rod, which receives its movement from the direct action of the exhaust cam upon its foot.

Inlet valve is opened by an overhead rocker of "H" formation, which is depressed by a tubular tappet rod. Round this tappet rod, at its base, a strong wire coil spring is mounted. This spring is clamped by a steel bridge piece to the crankcase, its function being to always press the inlet tappet foot firmly upon the duplicate inlet cam at its base. This cam is of circular formation with a flat at one side, and it is only when the inlet tappet is depressed by its spring into this flat that the inlet valve will be open.

Hardened steel shoes are fitted to the tappet rods to take the cam wear. Both tappet rods are adjustable, and steel studs are fitted in rockers above each valve stem to adjust clearance. The spring fitted to the inlet valve tappet must be of sufficient strength to overcome that on inlet valve when the latter is opened.

Breathers are fitted at either end of crankcase.

Each cylinder is secured to the crankcase by four long holding-down bolts with nuts above a stamped steel bridge piece, by four nuts on the same holding-down bolts clamping the cylinder base flange, and by four short stud bolts also clamping on the base flange.

Lubrication System.—A spur gear pump, fitted outside to the base of the sump, is driven from a bevel gear machined from the solid on the crankshaft. This pump gives one delivery of oil, which is conveyed via a suitable pipe to the propeller end bearing of the hollow camshaft. The oil passes along inside this shaft flowing out through a cross boring at each of the five bearings. It flows via a suitable transverse drilling in each bearing, down a boring in each of the crankcase partitions into the white metal bearings of the crankshaft directly below.

At each of the crankshaft journals there is a boring to the centre of the shaft, thence down inside the crank web to the crank pin, the oil flowing out through drillings to each big end bearing. The pistons, cylinders, cams, tappets, &c., are oiled by splash from the big end bearings. Holes are drilled to the inside of piston from a groove round it at the height of the gudgeon pin. This is to provide lubrication for the gudgeon pin bearing on the piston bosses. The rockers, &c., are oiled by hand before starting the engine.

Radiation.—A centrifugal water pump is direct driven from the rear end of crankshaft. It receives water from the base of the radiator and delivers it by two pipes to the base of the cylinder jackets on either side of the engine. Assisted by thermo-syphon, the water returns to the radiator by pipes from the tubular rocker supports.

Carburation.—A Schebler carburettor is connected by a "V" shaped pipe to two cast aluminium manifolds, each of which conducts

the petrol vapour to the four cylinders on that side of the engine. The vaporising chamber is water heated from the cylinder jacket. The jet which is mounted in a tubular passage is supplied by petrol, to a constant level, from a float chamber mounted concentrically to it. The level of petrol is regulated by a ring cork float operating a needle valve in inlet union. A single control lever simultaneously closes the throttle and depresses a "damper" into the jet. Fine adjustment between the throttle and jet damper is provided in two small levers on dials marked from 1 to 3, and a milled screw. Usual setting. Both dials with lever at Fig. 3 and $2\frac{1}{2}$ turns to milled screw.

Main air intake is from below the jet; but a purely automatic extra air valve admits air above jet. The valve is adjustable by a milled nut.

Thrust Race.—A ball thrust race, tractor, is fitted at propeller end of camshaft.

Ignition.—A Birling magneto, with self-contained distributor, is connected to the sparking plugs, in the order of firing.

Revolution Counter.—A spindle, to which the revolution counter may be fitted, is mounted upon the rear of camshaft.

Clearances, &c.:—

Inlet valve tappet	...	...	·01"
Exhaust ,,	...	...	·005"
Piston ring gap	...	...	·03"

Firing:—

Cylinders are numbered:—

1	3	5	7		
				8	→
2	4	6	8		

Fired:—

1, 2, 3, 4, 7-8-5-6

Timing:—

Inlet opens $\frac{1}{8}$ " after T.D.C.

„ closes $\frac{1}{2}$ " after B.D.C.

Exhaust opens $\frac{7}{8}$ " to $\frac{1}{2}$ " before B.D.C.

„ closes $\frac{1}{16}$ " after T.D.C.

Ignition, full advance $\frac{1}{16}$ "— $\frac{3}{8}$ " before T.D.C.

Full lift of inlet valve $\frac{1}{2}$ ".

„ „ „ exhaust „ $\frac{3}{8}$ ".

Diameter of both valves $1\frac{1}{8}$ ".

Oil in sump 3 gallons, normal speed of oil pump 1,544 revolutions per minute.

Pressure of oil up to 30 lbs. per square inch.

Petrol consumption 6-8 gallons per hour.

Oil

10 per cent. methylated spirit may be added to water of radiator to prevent freezing.

Weight of engine 325 lbs.

Length over all 49".

„ on bed 26".

Width over all 30".

Width on bed between bolt hole centres $12\frac{1}{4}$ ".

Height above bed 18".

Drop below bed $10\frac{1}{10}$ ".

Propeller on crankshaft, 8 ft. diam., 5 ft. pitch.

100 H.P. CURTISS OXX.

BORE $4\frac{1}{4}$, STROKE $5\frac{1}{4}$.

Details as per OX model with below mentioned differences.

Pistons.—Aluminium alloy with two cast-iron step cut piston rings in separate grooves.

Gudgeon pins mounted in connecting rods as before, the bearings in piston bosses, which are not bushed.

Ignition.—By a Birling magneto, mounted upon the crankcase, having two slip rings on the armature, and containing two distributors, wired to fire two plugs per cylinder, independently and simultaneously.

Alternately two Birling magnetos are mounted upon the crankcase to each fire one plug per cylinder. The ignition is synchronised.

CLERGET 80 H.P.

7 cylinder, radial, rotary crankcase.

Cylinders at $51\text{--}3/70^\circ$.

Bore 120 mm., stroke 155 mm., normal speed 1,200 revolutions per minute.

Anticlock.

Construction.—The crankshaft is in three parts:—

- (1) The main or back portion of crankshaft with first crankweb and outer crankpin.
- (2) The inner crankpin and second crankweb.
- (3) The small end of crankshaft or maneton.

Portions 1 and 2 are fitted together in Gnome manner, secured by an assembling nut.

Portion 3 is a driving fit in portion 2, and is prevented from revolving by a key. These pieces are held together by the crankcase, since one ball bearing is mounted on piece 3 in cambox, while others are mounted on piece 1 in thrust box.

The crankcase is in two halves, bolted together round the cylinders. The latter have one flange, round the outside of the skirt, near base, which fits in a corresponding groove in the crankcase.

The cylinders are turned from solid steel with radiating fins, and are prevented from rotating by a small circular key. The seating of both valves screw directly into the cylinder head. A copper asbestos washer is fitted below the exhaust valve seating. The inlet valve seating is cast in one piece with inlet port and forms a metal to metal joint with the cylinder head.

The exhaust valve is of mushroom type, with coned face to seating.

The inlet valve is of similar type, but has a flat surface seating.

Both valve springs are light, since centrifugal force exerts a strong pressure to close valves.

Pin keys are fitted to top of valve stems.

Two rocker supports screw separately into cylinder head.

The rockers are of cast steel with weights over valves, to counter-balance the effect of centrifugal force on tappet rods.

The rocker fulcrum pins have a V or knife-edge on their underside. They are prevented from revolving by a key meshing in a key way in rocker support; and since the rockers are flung outward when the engine revolves they will bear on the V of the fulcrum pin.

The long tappet rods, adjustable with locking nut, have a ball and socket joint at either end. The tappets are mounted in two layers or planes in the cambox, the inlet tappets nearer the centre of the engine. The feet of the inlet and exhaust tappets are of different shape. Those for inlet have a single wave formation, while those for exhaust have a double wave.

The tappet guides are of phosphor bronze mounted in the cambox, which is of shell formation, turned solidly with the front half of the crankcase.

The cam gearing consists of two rings internally toothed with 14 teeth, each mounted within the cambox and keep to it, with suitable distance pieces. These rings will drive the two camplates, which are mounted upon the small end of the crankshaft, keep to it, to revolve, but with their centres offset. These camplates have 12 teeth, meshing with the toothed rings in cambox. Three cams are projected at the back of each camplate, and will, in turn, engage with the tappet feet raising the valves. The thrust box is bolted to the rear of the crankcase. It contains two large radial ball races and thrust bearings. These bearings are so mounted that if the engine is tractor the thrust is taken from a steel flange turned solidly inside the thrust box to a large steel washer fitting firmly on crankshaft, and through a distance ring to inner steel ring of the radial ball race mounted against first web on the crankshaft. When engine is "pusher" the thrust is taken from the other side of the flange within the thrust box to a large steel washer keyed to it; then via a ball thrust race to a smaller steel washer fitting tightly on crankshaft, and through the inner steel ring of radial ball bearing and oil fling ring to a locking ring screwed on to the crankshaft. The crankshaft is mounted in the back plate, with the crankpin or throw upwards.

A master connecting rod is mounted on two ball bearings on the crankpin, and the six small connecting rods are mounted upon wrist pins in the master rod, the wrist pin mountings on the master rod being staggered as in Gnome engines.

The connecting rods are circular in section, taper to the gudgeon ends, from which end they are bored down the centre with a $\frac{1}{4}$ -inch hole (about). Six nipples are turned for oiling purposes in the master rod below the centre of wrist pins; these nipples are countersunk at their base.

The small connecting rods are bushed at both ends with phosphor bronze, and slotted to admit oil at wrist pin end. The master rod is bushed phosphor bronze at gudgeon pin end.

The pistons are cast iron, saucer topped, cut away on trailing edges for clearance at lowest portion of stroke. Three piston rings are fitted in at separate grooves above the gudgeon pins. These rings are of 2 mm. wide by 8 mm. deep. Two obturator rings are mounted concentrically at the piston head. Of these rings the inner one is the more widely coned. The gudgeon pin is of solid steel, secured with one set screw through the piston boss. The set screw is locked by a split pin.

To Build up Engine.—Mount internally toothed ring marked A.D.M. in the cambox, with the lettering visible. Insert all tappets in guides. Mount maneton in second crankweb and insert the former in its bearing in the cambox. Mount the cylinders in position between two halves of the crankcase, and later place all pistons, with their connecting rods attached, in their respective cylinders and insert wrist pins. The main portion of the shaft having been mounted and secured by the assembling nut, thrust box complete should be bolted to the crankcase. After the engine has been mounted in the backplate, the valves, rockets and tappet rods can be successfully built on.

The valve clearances should be in each case 1 mm.

To Time Inlet Valve.—Rotate the engine anticlock until No. 1 cylinder is 50° past bottom dead centre.

Mount the camwheel marked A.D.M. upon the crankshaft with the lettering visible, in such a position that any one of the three cams will be just allowing the inlet valve of that cylinder to close.

To Time Exhaust Valve.—Rotate engine until No. 1 cylinder is 68° before bottom dead centre, anticlock, on power stroke. Insert the internally toothed ring marked E.C.H. in the cambox with the lettering visible. Mount cam wheel marked E.C.H. upon the maneton, also with lettering visible, so that any one of the three cams is just opening the exhaust valve of No. 1 cylinder. Mount small bearing and locking nut upon maneton and put oil retaining cover on cambox.

Clearances.—With each cylinder at 50° after bottom dead centre on compression stroke, adjust the valve clearances so that the inlet valves successively close at this precise point.

If reasonable care is used it will not be possible to mount the cam wheels wrongly, for as they have but 12 teeth an error of one tooth in the meshing is self-evident.

The exhaust valve closes at top dead centre to 5° late. The inlet valve opens at top dead centre.

Carburettor.—A carburettor of Gnome flowing jet type, or one in which a single lever operates a throttle and simultaneously depresses a taper needle into a flowing jet, is fitted to the rear end of the hollow crankshaft. This supplies petrol vapour to the crankcase, whence this is drawn through elliptical section steel pipes to the inlet valves. These pipes are bolted by a flange to inlet portions, but a sliding fit in pockets in the crankcase, with leather packing washers and steel compression plates. This form of fitting is to allow for expansion in

the cylinders. A hole of 1 cm. in diameter is bored in each inlet pipe, towards the top, open to the air.

Ignition.—A Bosch or American-made magneto is fitted to the backplate driven at $7/4$ engine speed from a spur wheel on the thrust box. The high tension current is taken to a carbon brush suitably mounted upon the backplate, which latter conducts the current to a distributor, of Gnome type, mounted upon the thrust box. The distributor sectors are connected by bare wire to the sparking plugs.

Lubricating System.—A plunger type pump is fitted to the backplate driven at $7/4$ engine speed from a spur wheel on the thrust box. The pump is kept filled with oil by gravity from the tank. This pump gives one delivery of oil, which is led to a union upon the backplate and a branch pipe to pulsator glass. A hole in the crankshaft, at a corresponding position, allows the oil to flow along a copper pipe within the shaft to a boring up the first crank web. At a point level with the top of the crankshaft, a small cross bearing allows a portion of the oil passing up the crank web to flow to the thrust box; the remainder of the oil flows up the web to an annular space between the inner and outer crank pins. From here it can pass through a cross boring in the outer crankpin to the centre of the master connecting rod; thence up the hollow rod to the gudgeon pin, or out through the six nipples to the wrist pins and round the wrist pin bearings up the hollow connecting rods to their gudgeon pins. Oil can pass to the cylinder walls through four holes in the piston sides below the head.

A portion of the oil from between the two crankpins will enter a boring in the inner pin, pass down a drilling in the second crankweb into the hollow maneton, whence it will flow to the inside of cambox. Surplus oil in the thrust and camboxes will accumulate until it can pass to the crankcase through the main ball bearings, or pass out through the tappet guides. Castor oil is used, as it does not form a mixture with the petrol vapour in the crankcase, has a high flash-point, and retains its viscosity while hot.

Petrol consumption	...	6—8 gallons	per hour.
Oil	„	1—1½	„ „ „

The propeller is fitted to a nose piece of suitable design for the type of machine. The nose is bolted to the cambox.

Actual h.p. 85 B.H.P. Weight 256 lbs.

CLERGET 100 H.P.

9 cylinders. Radial at 40° . Bore 120 mm. Stroke 160 mm.

Construction varies from the 80 h.p. model in that the crankshaft is in two pieces :—

- (1) The main shaft first web and inner crank pin.
- (2) The outer crank pin second web and small end of crankshaft.

The cambox is separate from the front half of crankcase and bolted to it.

This construction enables a mechanic to remove all the connecting rods and pistons from the engine, while the latter is still in the aero-

(B 12865)

c

plane, if he has previously removed the cambox and small end of crankshaft.

The pistons are of aluminium alloy, but the compression rings are as in the 80 h.p. model. Cast-iron pistons were formerly fitted, having steel gudgeon supports or cross-heads secured to the piston by a large bolt through the head.

Two magnetos, a double distributor and two plugs per cylinder are incorporated in the dual ignition system.

The obturator rings are an alloy of 80 per cent. silver, 20 per cent. copper or muntz metal.

The actual h.p. is 180 to 150 B.H.P. on three hour test. The weight 380 lbs.

To find angle of cylinders for timing purposes, the makers use a graduated plate with gravity needle. This is applied to the top fins of the cylinder, which are parallel to the bore.

Alternately the angle may be judged, with fair accuracy, by positioning the cylinders to approximately the angle, as in the Gnome timing.

7-CYLINDER MODEL.

Inlet closes 50° after B.D.C.

Therefore if No. 1 cylinder is 50° after B.D.C., No. 2 cylinder must be $1\frac{1}{2}$ before B.D.C., since angle between the cylinder is $51\frac{1}{2}$.

Similarly, if No. 1 cylinder is 68° before B.D.C., No. 5 cylinder will be 30° below the horizontal to the right.

The markings A.D.M. and E.C.H. on camplates indicate "Admission and Echappement" inlet and exhaust, since the engine is of French construction.

NOTES ON ROLLS-ROYCE AERO ENGINE 250 H.P.

Crankshaft and Bearings.—Crankshaft is made of chrome nickel steel, hollow and supported by seven white-metal bearings. Conical cups connected in pairs are for sealing up hollow crankshaft.

Side clearances of bearings are 25/1000, except epicyclic gear which is 112/1000 flanged bearing.

Bearings have gunmetal backs, distance pieces white metal tipped are fitted.

When replacing crankshaft always leave out No. 1 bearing (flanged) until crankshaft is properly bedded down, when it should be slipped into place.

Crank pins are set at 120° :—

1—6, 8—4, 5—2.

Connecting Rods.—Connecting rods are made of Ferth-Chrome Vanadium steel. They are made in pairs; one, the articulating rod is attached to the main rod by special joint and locking device. Articulating rods *always* lead. Cylinders are set at an angle of 60° , whilst the included angle between main connecting rods is 65° . On

the articulating joint it is most important that the small slot cut for snug pin corresponds with slot cut for pin. Should this not be observed the oil supply to gudgeon pin would be cut off and engine seize up.

Articulating Rods on Starboard Engines.—These operate in the A. cylinders.

Articulating Rods on Port Engines.—These operate in B. cylinders.

Gudgeon Pins.—Are hollow and of case-hardened nickel steel screwed by flange on one end and by locking piece fitted into slot the other, which also cuts into gudgeon pin boss.

Pistons.—Pistons are made of aluminium alloy and are described as Scraper Pistons, Zephyr Type.

Old type 2 rings and 1 scraper.

New type 3 rings and 1 scraper.

In the new type part of skirt is cut away.

Ring gap is 15/1000.

Weight of old type 2 lbs. 2 ozs.

„ „ new type 2 lbs. 12 ozs.

Cylinders.—Are made of carbon steel, .6 per cent. bored from solid; exhaust ports have deflectors on flange. At base of cylinders two small holes are drilled, one on either side to take dowel pegs on crankcase, which position cylinders. Take care not to force these into the crankcase.

Cylinders are water jacketed by welding on a jacket of thin charcoal steel.

Oil Pump.—The oil pump consists of two small pinions, which are fitted to phosphor bronze casing; half the teeth of either pinion are always in contact with casing.

The ends of pinions are also in contact with bottom half of cover. In cover two valves are fitted; one is to maintain the pressure in the main pipe, of 35 to 40 lbs. per square inch. Oil which passes the first valve enters a small port, and is by action of a second valve opening allowed to return to sump, but the oil is kept at a pressure of 2 to 3 lbs. per square inch in the port and a lead is taken off at this point to supply all other parts of engine.

Oil Pump Driving Gear.—Oil pump driving wheel is in direct contact with crank shaft pinion, but only having two-thirds of the number of teeth of that pinion its speed is increased $1\frac{1}{3}$ to 1. As this is unnecessarily high for large pump to deal with and amount of oil required, an epicyclic reduction gear is used, reducing pump speed to cam shaft speed. Pumps of port and starboard are interchangeable, but not pump drives.

Filter.—Consists of aluminium cylinder with cylindrical wire gauze inside.

Lubrication.—Is from tank to pump, which delivers oil to main bearings, at a pressure of 35 to 40 lbs. per square inch through hollow crankshaft to crank pins, oiling big ends of connecting rods, up tube on connecting rod to gudgeon pin, surplus to cylinder walls. A lead is taken from high-pressure pipe to reducing valve, converted to 2 or

3 lbs. pressure and conveyed to the wheel case lubricating timing gear, then to cam shaft, lubricating reducing gear also.

NOTE.—Dry sump in new type engines; and ball valve and sump containing 27 pints of oil in old type.

Spring Drive.—Spring drive is to make a flexible connection between crank and main driving pinion, to prevent any shock being transmitted to the gearing. It consists of 12 springs acting on clutch plates, with fibre washers in between. There are eight springs placed circumferentially to take the drive, and the springs are combined with clutch plates to counteract the springing back of engine.

To Set up Reduction Gear.—Remove small ball bearing from crankcase extension bolt, empty gear case with nose bearing housing B. in place upon it, the setting up screws run back, and eight nuts which fasten it to gear box slacked off. Push the special setting up to disc on crankshaft extension, set up the housing until the disc can just be turned freely by the fingers, then lock setting up screws, taking care not to disturb the housing. Tighten up the eight nuts on front flange of gear box. Gear box may now be removed and gear erected in it.

To Take Down Gear.—Break joint between crankcase and gear box, when the gear may be pulled bodily from crankshaft. Next unscrew nuts on nose and pull shaft backwards out of nose bearing by tool provided.

Description of Epicyclic Gear.—Epicyclic gear reduces crankshaft speed to propeller speed 36 per cent. The operation of gear is, A by having an annular gear of 120 teeth cut inside flywheel of crankshaft. The flywheel drives a set of three planets. B, cast with 45 teeth, directly connected with the same spindle with planet wheels. C, each with 30 teeth, which rotate around sun-wheel, 45 teeth. The sun wheel is stationary and is locked to gear box by sun-wheel locking cogs or teeth on gear case.

Water Pump.—Water pump is centrifugal type, pumping 24 gallons per minute. Water is circulated around water jacket, vapour rising to top of cylinders to radiators and tanks, where it continues and returns through radiators to pump. Induction pipes are heated by a separate pipe which returns through radiator to pump. Pump drive, $1\frac{1}{2}$: 1 ratio. Delivery 24 gallons per minute.

Hand-starting Device.—The hand starter is an epicyclic gear 6 : 1. It engages by means of a spring plunger. Attached to spring drives are corresponding dogs. Lever holds gear in position when starting, when engine fires it overruns the clutch and throws gear out of mesh. Hand-starting magneto is coupled to distributor of running magneto.

Valve Lift.—Springs are two in number and are wound in opposite directions, and placed one inside the other to prevent turning.

Priming Device.—Priming device should be filled with petrol; petrol then raises ball valve and finds its level in the pipes. Set lever at "Tank," give about ten strokes of pump, then set "priming device," and another six strokes forces petrol into induction pipes.

Do not over-prime, as engine will be hard to start on rich gas.

To Time Valves.—Turn engine until M.R. shows on annular wheel, then turn camshaft until 6 A shows at inspection hole, then

mesh wheels; at this point exhaust valve No. 1 A will be closed and inlet about to open, whilst 6 A is on firing position.

Details of Thrust.—

1. Distance piece, outside one.
2. Washer—single thrust.
3. Wide distance piece. Large.
4. Ball race.
5. Double thrust washer.
6. Ball race.
7. Small distance piece. Narrow.
8. Single thrust washer.
9. Roller bearing.
10. Locking washer (thin steel).
11. Locking ring to propeller shaft.
12. Cap of thrust box castellated.

Firing Sequence.—1 A / 6 B / 4 A / 3 B / 2 A / 5 B / 6 A / 1 B / 3 A / 4 B / 5 A / 2 B /.

MISCELLANEOUS NOTES (ROLLS ROYCE).

Valves.—Conical hollows in heads, stems are drilled both ends, they are made of Tungsten steel set at 50° included angle.

Propeller.—In direct drive 36 per cent. reduction of engine speed. Ratio 64 : 1.

Double Valve Springs :—

Strength closed, 38·5 lbs.

“ open, 49·5 lbs.

White Metal Bearings. *Thrust.*—Ball race.

Camshaft.—Hollow for oil lead, carried in three split phosphor-bronze bearings overhead and encased.

Rev. Counter.— $\frac{1}{4}$ of engine speed.

Carburettors.—Two double ones—Claudel-Hobson type.

Revolutions of :—

R. P. M.

Oil pump	=	775	=	1,600	Engine speed.
Water pump	=	2,400	=	1,600	“ “
Propeller	=	1,024	=	1,600	“ “

Cylinders.—Bore $4\frac{1}{2}$ " , Stroke $6\frac{1}{2}$ " . Made from 6 per cent. carbon steel and bored from solid.

Water Jackets.—Thin charcoal steel plates pressed and hammered into shape and welded on to cylinders.

Weight of cylinders is 12 lbs. 5 ozs.

Pistons :—

Weight, old type—2 lbs. 2 ozs.

“ new type—2 lbs. 12 ozs.

Lubrication Pressure.—High pressure of 35 lbs. per square inch to main bearings. Low pressure 2 to 3 lbs. per square inch to camshaft, timing wheels, &c.

Engine Weight.—830 lbs., less radiators.

Valves.—Are set at an angle of 35° , and guides are phosphor-bronze and driven into position.

Petrol Consumption.—20 gallons per hour.

Oil Consumption.—6 pints per hour (Wakefield's Castrol is used).

Cooling Circulation.—24 gallons per minute. Temperature of water = 80° F.

Maximum Advance of Ignition.— 35° .

Direction of Rotation:—

Portside engine	} Inwards on pusher.
Starboard engine	

Camshafts.—Two. Air pump is driven from A. Rev. counter is driven from B.

Water Carried in Engine and Pipes.—8 gallons. Total water carried, 12 gallons.

Tapet Clearances:—

Inlet .008.

Exhaust .015.

Cycle of Operations:—

Inlet opens	=	10°	P.T.D.C.
Inlet closes	=	54°	P.B.D.C.
Spark	=	35°	B.T.D.C.
Exhaust opens	=	58°	B.B.D.C.
Exhaust closes	=	10°	P.T.D.C.

DIAGRAMS AND NOTES ON MACHINES.

(See Plate 38.)

INSTRUCTIONS FOR ERECTING AND TUNING DE HAVILLAND 2 MACHINE (WITH 100 MONO. GNOME).

Main Planes.—All main plane struts are set at right angles to top rail of nacelle (except rear centre struts).

The top and bottom planes are interchangeable.

Dihedral.—A string stretched across top plane between outer struts should measure $9\frac{1}{8}$ " above top of middle struts. This dimension can vary slightly without bad effects.

Incidence variation for Torque.—The amount of extra incidence on one side to counteract propeller torque is best found by practice. If the machine flies right wing down, wire more incidence that side. If this is difficult owing to adjustment of wires, wire *less* angle on left wings. In all cases the incidence must only be varied in outer bay of wings. The incidence wires at end of tail booms should be equal both sides.

Wash Out.—There is no necessity for wash out in wings (of course, excepting that necessary from torque as explained above).

Ailerons.—Trailing edges should be adjusted about one inch below main plane trailing edge when machine is on ground.

Tail Booms.—With top nacelle rail *horizontal* and main struts

vertical the tail booms should be symmetrical, i.e., the tail boom struts *vertical*, and making the same angle with the booms top and bottom.

Tail Plane and Different Load.—Tail plane should be set so that the machine flies horizontal without any load on elevators when the normal load is taken in front. Normal load being gun and ammunition, or a weight of 40 lbs.

Rudder.—When flying, the rudder is over slightly to the left. The rudder bar should be adjusted to be straight when the rudder is in this position. A spring is provided on rudder bar to take this load.

Undercarriage.—In the event of repairs to the undercarriage, the machine should be supported by trestles directly under front and rear intermediate struts. It may be supported on nacelle at extreme rear, but this is less convenient.

The axle used is exactly similar to Standard B.E. axle.

INSTRUCTIONS FOR ERECTING AND TRUEING DE HAVILLAND 1 MACHINE (WITH RENAULT OR BEARDMORE ENGINES).

(See Plates 34 and 35.)

Main Planes.—All main plane struts are set at right angles to top rail of nacelle (except rear centre struts in Renault machine).

Dihedral.—A string stretched across top plane between outer struts should measure $5\frac{1}{8}$ " above top of middle struts.

Incidence variation for Torque.—The amount of extra incidence on one side to counteract propeller torque is best found by practice. If the machine flies right wing down, wire more incidence that side. If this is difficult owing to adjustment of wires, wire *less* angle on left wings. In all cases the incidence must only be varied in outer bay of wings. The incidence wires at end of tail booms should be equal both sides.

Wash Out.—There is no necessity for wash out in wings (of course, excepting that necessary from torque as explained above).

Ailerons.—Trailing edges should be adjusted about one inch below main plane trailing edge.

Tail Booms.—With top nacelle rail *horizontal* and main struts *vertical* the tail booms should be symmetrical, i.e., the tail boom struts *vertical*, and making the same angle with the booms top and bottom.

The side bracing wires from outer planes to middle tail boom struts should be slack, otherwise tail boom struts will vibrate badly.

Tail Plane and Different Load.—Tail plane should be set so that the machine flies horizontal without any load on elevators when the normal load is taken in front. Normal load being gun and ammunition. If a passenger is not carried, a load of 100 lbs. should be placed in the nose of the machine, near front rudder bar.

The machine must not be flown without weight in front.

Rudder.—When flying the rudder is over slightly (the direction depending on Renault or Beardmore engine).

The rudder bars should be adjusted to be straight when the rudder is in this position. A spring is provided on rudder bar to take this load.

Undercarriage.—In the event of repairs to the undercarriage, the machine should be supported by trestles directly under front and rear intermediate struts, or it may be supported on nacelle at extreme rear and front.

The axle is similar in dimensions to B.E. 2 axle.

Changing Bottom Plane :—

1. Place trestle under rear end of fuselage to take weight off tail skid, and under front end of fuselage to balance machine.
2. Disconnect bracing wires from tail boom.
3. Disconnect main plane lift wires.
4. Place trestle under tip of bottom plane and remove landing wires.
5. Prop up top plane safely.
6. Remove pins from bottom end of main plane struts and bolts holding planes to fuselage.
7. Disconnect ailerons.

New plane should be laid out on trestles, and eyeplates and strut eyebolts should be changed to new plane.

Fit new plane as dismantled (reverse of above).

(Top and bottom planes are interchangeable.)

Changing Tail Booms :—

1. Place trestles under front and rear ends of nacelle.
2. Disconnect at rear end, rubber and elevator controls.
3. Remove first bay of tail boom wires and tail boom bracing wires.
4. Lift tail away from main planes.

Fit new booms as above.

Changing Rudder Post :—

1. Place trestle under rear tail boom struts.
2. Slack off bracing wires in rear bay of tail booms and wires to tail plane.
3. Disconnect rudder controls and tail skid controls.
4. Remove eyebolts through tail booms, bolt at rear of tail plane and bolts through tail plane.

Remove fittings from old rudder post to new rudder post, and replace as above.

Changing Landing Chassis :—

In changing the landing chassis, it is well to remember that the machine should be propped up as follows :—

“ Place a trestle under first upright strut from front of nacelle, and a trestle under rear of nacelle immediately behind chassis strut socket.”

R.E. 7 DETAILS.

(See Plates 86 and 87.)

The machine should be levelled up by engine bearers, for both fore and aft and laterally. A reading should also be taken for fore and aft by bisecting the fuselage struts, which should give the same result as the engine bearer.

Stagger.—Top plane forward, 2.89 inches.

Incidence.— $30^{\circ} 6'$ mins. on right and left hand planes.

Originally $\frac{1}{2}^{\circ}$ wash out was given on right hand planes, but this has been deleted. For first flight right and left hand planes are set equal $30^{\circ} 6'$, and sometimes slight adjustment is required on right hand planes, viz.:—Incidence slightly decreased, but this seldom exceeds 10 minutes on wing measured at outer strut.

NOTE.— $30^{\circ} 6'$ should be obtained on bottom planes.

There may be a slight variation on top planes, which, however, cannot be corrected without altering strut lengths, which is unnecessary.

Dihedral.— $20^{\circ} 30'$ on front spars. (1 in 25.) Equivalent measurement— $7''$. If this is obtained on front spars at top planes, bottom planes should come right automatically.

Centre line spar sockets to centre line of undercarriage axle = 7.5 inches.

Ailerons.—To be set sufficiently down on trailing edge to come level in flight. Approximately $\frac{1}{4}''$ with machine on ground.)

F.E. 2.B. WITH 120 H.P. BEARDMORE AERO ENGINE.

(See Plates 32 and 33.)

Level up machine by nacelle members, both fore and aft, and laterally. In this position the struts of the tail booms should be symmetrical.

The outer planes and ailerons are interchangeable with those used on the B.E. 2.C.

Incidence.— $3\frac{1}{2}^{\circ}$ or $4''$ with straight-edge and rule. (With new section planes, the incidence is $40^{\circ} 20'$.)

Dihedral.— 40° or $10\frac{1}{2}''$, with strings on front spar between outer struts.

Wash out.— $\frac{1}{2}^{\circ}$ on left plane.

Stagger.—Nil plus $\frac{1}{4}''$.

Gap.— $8' 3\frac{1}{2}''$.

Chord.— $5' 6''$.

Total Area of Main Planes.—490 square feet approximately.

Backswept.— $72'$ at outer struts.

Height.— $11' 9''$. Span $47' 9''$. Length with gun $32' 10''$.

Weight (with full tanks) = 2,600 lbs.

Average setting of tail plane between top of tail booms and bottom of rear spar of tail plane = $3\frac{1}{2}''$.

The elevators are interchangeable.

It might be noted that, while usually known as such, the tank under the top plane is not a "Service Tank," and would be much better described as an "Auxiliary" or "Emergency Tank."

VICKERS SCOUT.

(See Plates 30 and 31.)

The machine is levelled up by the engine bearers, both longitudinally and laterally.

Angle of Incidence.—0° on all planes.

Dihedral.—1·4" measured from line joining top of packing blocks above interplane struts, to top of packing blocks above centre section struts.

Stagger.—None.

DIRECTIONS FOR TRUEING UP PLANES OF SOPWITH 110 H.P.

CLERGET 1½ STRUT TWO-SEATER TRACTOR BIPLANES.

(See Plates 28 and 30.)

1. Adjust centre section wires to give 24" stagger.
2. Tighten front weight wires " A " to raise centre line of bottom front spar 6½" above centre line of bottom front centre section spar at tip as shown.
3. Adjust stagger wires " B " and " C " tip lengths given in table below.
4. Tighten back weight wires and all lift wires so that " A," " B," and " C " are just tight. Lock all wires. This will give a wash in on starboard side and a wash out on port side.

Lengths of Outside Stagger Bracing:—

<i>Port</i>	B.	...	...	...	Length 6' 11½".
<i>Starboard</i>	B.	...	...	...	" 7' 0".
<i>Port</i>	C.	...	...	...	" 5' 0".
<i>Starboard</i>	C.	...	...	...	" 4' 11½".

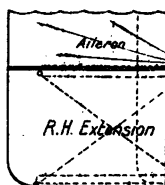
These lengths are measured between centres of Shackle pins.

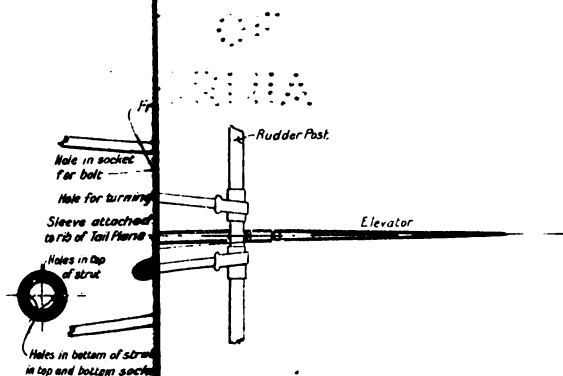
NOTE

ken in cutting struts D.E.N & P as these must support Nacelle
ing Position, in order to give Propeller a perfectly horizontal
elage, Tail Booms must be perfectly straight with struts V.W&X
ts G.R & F.M. Diagonals of Cross Bracing Wires to be exactly
achine in Flying Position Rear Elevator should be set with a droop
es below the line of rear part of Tail Plane, when control bar is
erons should be set with a droop of the same amount below the
t & Left End Planes see Figs 7 & 6 Sheet N°3.

For adjusting fuselage
dimension between struts
to corresponding dimensions
struts K & X at other

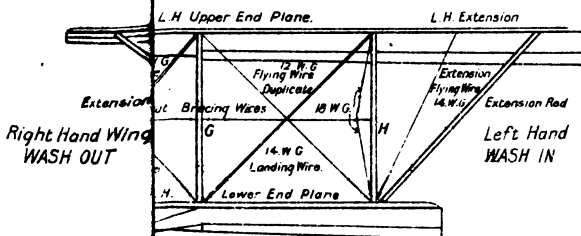
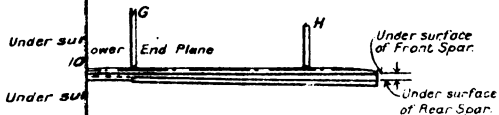
Anti
Drift





Front Spar of
Rear Spar Raised
measured under

Front Spar L.H End Plane perfectly horizontal
Rear Spar Dropped a distance of 10 Millimetres.
measured under outermost rear strut.



Front Spar
straight line
Rear Spar
straight line

Front Spar L.H Extension perfectly horizontal forming
straight line with front spar of L.H. Upper End Plane.
Rear Spar of L.H Extension Dropped at outer end to form
perfectly straight line with Rear Spar of L.H Upper End Plane.

Upper
 (Level in Flight)
 Nace
 Elevating Rod
 Lever
 Lower Main
 Undercarriage
 Front Strut
 Front Skid

SHOWING SETTING OF TAIL PLANE & ELEVATOR.



In Position place a straightedge with one end touching the bar, bring to the horizontal, and adjust Tail Plane to give a millimetres as shown. Note that this dimension Must Not exceed in neutral position. Elevator should be set with a droop of below the line of rear part of Tail Plane as shown. This is position of the controls under stress while flying.

Square

Plumb Line

Leading Edge
 (Front Spar)

Undercarriage
 (Front Strut)

Instead of plumb vertical. The lower Front Spar & Tail in dotted Lines

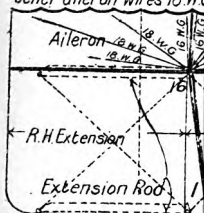
WIRE OF
STRUCTURE

be taken in cutting struts 4, 5 & 12, 13 as these must be perfectly level in Flying Position in order to give perfectly horizontal thrust.

Duplicate, tail booms must be perfectly straight parallel in planes, with struts 17, 18 & 19 directly in rear of struts 20 & 21 directly in line with centre of Nacelle & middle bay exactly equal in length.

Dimensions (X) between outer front struts (19) & rear struts (9 & 16) of Main Cell. These should be equal on either side.

Aileron King Post
Wires immediately behind
other aileron wires 18 W.G.



Main Plane
cross bracing
14 W.G. shaft

Outer
Aileron Control
Duplicate

Front into
are numbered
left facing

TAIL CELL.

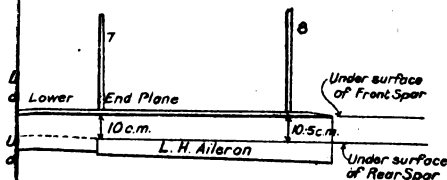
With control
of front elev
until training
below natural
Obtain set
Ailerons 5
a similar
left hand
aileron is
and compe

Front and rear spars of upper and lower Tail
Planes perfectly straight, level and parallel.
Incidence on lower plane 35 millimetres
measured between under sides of & front spars

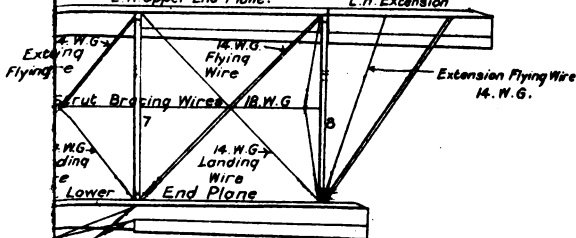
Note that this dimension
MUST NOT be exceeded.

1/2 in King Post
1/2 in W.G. Wiring
1/2 in Compensating
1/2 in 16. W.G.

Front interplane struts are numbered 1 to 8 from right to left.
Rear do. do 9 to 16 from left to right.



Front & rear spars centre section both upper
lower planes, curved upwards of centre a
distance of 9 millimetres as shown. Ends at struts
(11 & 14 at rear) lie in the same horizontal lines.
L.H. Upper End Plane. L.H. Extension



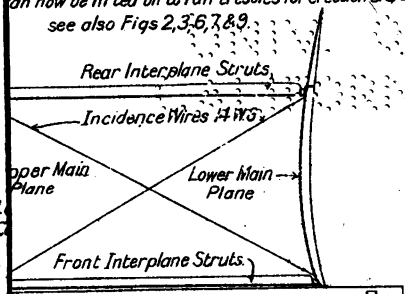
Both
Diagonal
Rear
control

LEFT HAND WING WASH IN.

Both front spars perfectly straight level & parallel
Diagonals equal. Rear spars parallel.
Rear spar of L.H. Extension Drooped to form a
continuation of rear spar of L.H. End Plane.

Fig.5 ASSEMBLING MAIN CELL.

Sections of lower plane and upper plane minus extensions.
 of fabric over joints on both surfaces. Fix sockets.
 on leading edges and insert struts 1, 16, 8 & 9 and
 incidence wires. Then fix remaining struts & insert all
 flying & landing wires
 can now be lifted on to fall trestles for erection & trussing.
 see also Figs 2, 3, 6, 7 & 9.



NOTE When reerecting repaired planes care must
 be taken to use the old in sprs as reborning
 makes them DANGEROUSLY WEAK.

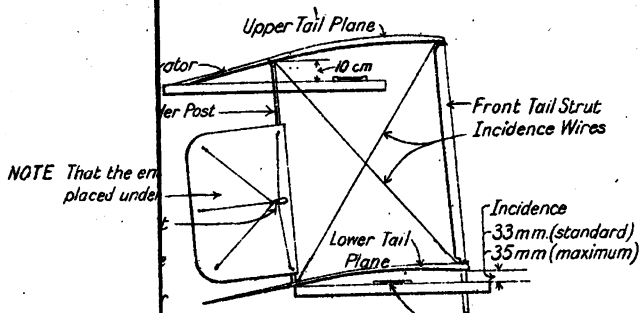


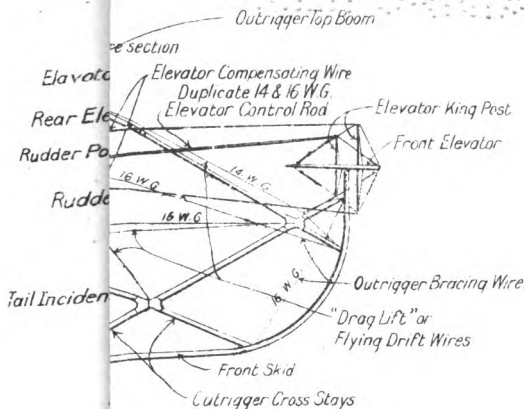
Fig.8. Straightedge and Level.
SIDE ELEVATION OF TAIL CELL.
 see also Fig. 4.

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OUTRIGGERS.

With control
surface fully
compensated
drags. Obtain correct
Ailerons sought
below the
This is the
while the

Outriggers should be the same
distance apart in front as in
rear, with the centre kingpost
of front elevator directly in
line with centre of Nacelle



UNDERCARRIAGE

For lateral must be perfectly vertical viewed from the front
For vertical beneath interplane struts Nos 3 & 6, 11 & 14.
equal and plumb line from leading edge of lower main plane
boom is 19 centimetres in advance of this line.
This strut is 19 centimetres in advance of this line.
above should then be 37 cm to the rear of the line.
tail cell, line from leading edge of upper main plane to
These line skid where it joins front skid. Measuring from
above upper edge of lower main plane should show
fig. 6.

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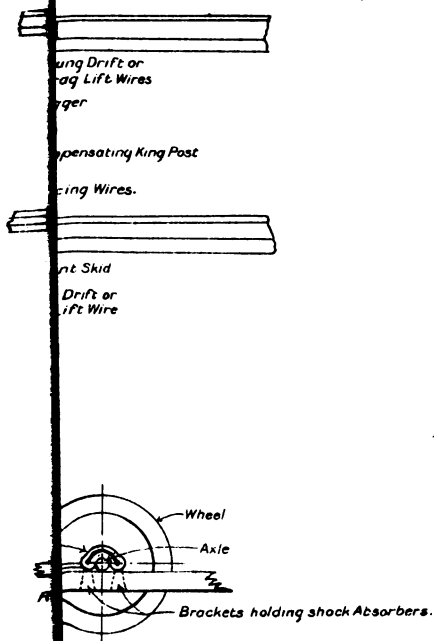


Fig.12.

UNDERCARRIAGE SKID.

Show Shock Absorbers and radius rods.

Centre
parallel
Viewed out
centre
outward
Check

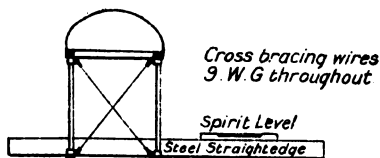
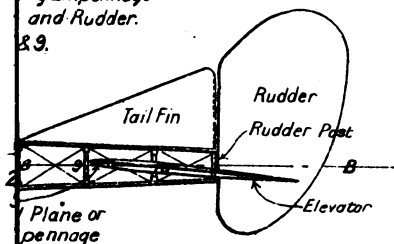


Fig. 2.
CROSS SECTION OF FUSELAGE

ing Empennage
and Rudder.
& 9.



side bracing wires 9 W.G throughout

FUSELAGE ADJUSTMENT

level laterally, true fuselage for square transversely and making cross bracing wires exactly equal in length. Make square viewed from the front. Continue from front edge and spirit level laterally across lower longerons close and adjusting cross bracing wires in each successive bay until perfectly level laterally throughout length of fuselage.

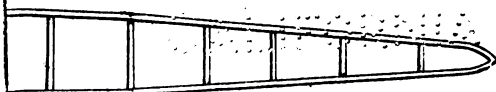
Under and all side struts except No 4 (steel strut carrying elevator) from front to rear should cut all side struts at the points when tightening or slackening side bracing wires and after each brace bracing wires. Both sides should be adjusted at the same time. For level position this line is perfectly level. Check by spirit level the points of bisection of side struts. In this position the upper longerons in the first three bays should also be quite level. The strut 4 should be $\frac{1}{16}$ in. above centre line.

see also Fig. 3.

FUSELAGE.

Fuselage must be perfectly level laterally. Check with straightedge & Spirit Level across engine bearers as Fig 4. see also Fig 1 & 2.

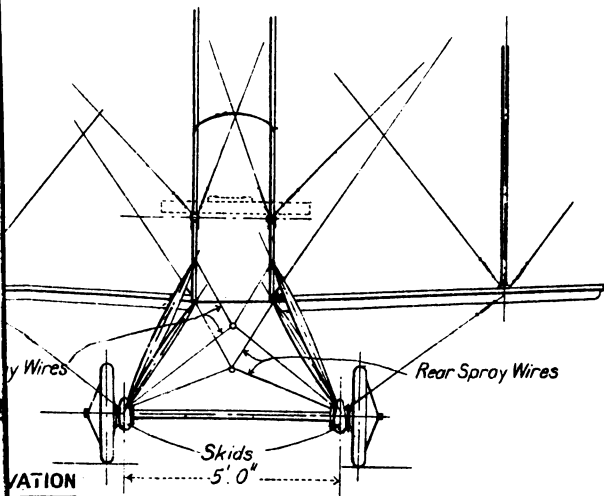
Fuselage must be perfectly straight & Symetrical about the centre line. Check by measuring from the centre of Rudder Post to bolt under outer rear strut, over main plane at either side. These dimensions should be exactly equal. For adjustment of Tail Fin Empennage, Elevator, & Rudder see Figs 8 & 9.



Strut

Down cable.

LATER

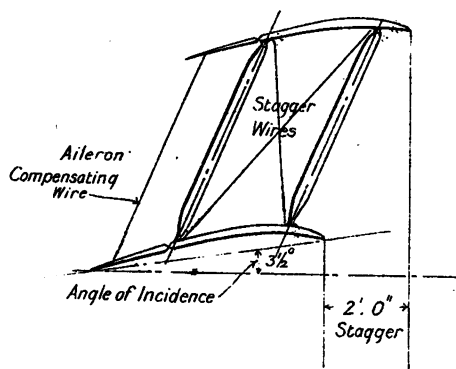


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Fig.6. SIDE VIEW.



DIHEDRAL

STAGGER

SQUARE

CENTRE
SECTION

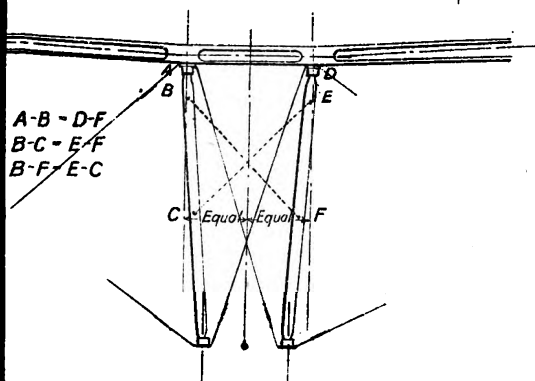
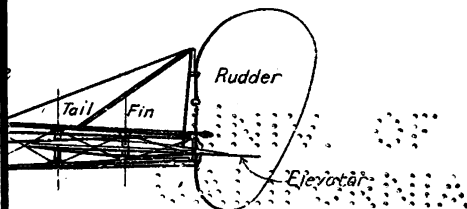
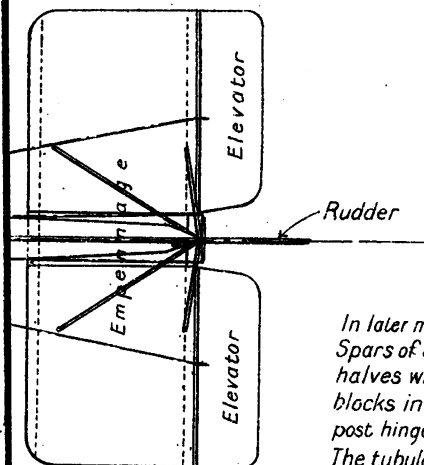


Fig.7. CENTRE SECTION.

CONTROLS.



TO FIT



RUDDER

ELEVATORS
AND
AILERONS

NOTE

*In later machines front and rear
Spars of empennage are in two
halves with bolt connections to
blocks in fuselage and on rudder
post hinge bracket.
The tubular stay rods are also
replaced by cables & R.A.F. wires.*

Fig.9. PLAN OF EMPENNAGE ETC.

umb line from
from this line to
res.
ent. In flying
side.
are should be
ould make

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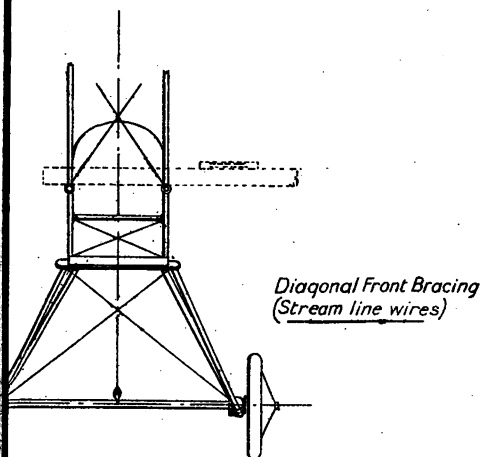


Fig. II.
FRONT VIEW OF "V" TYPE.
UNDERCARRIAGE.

NOTES

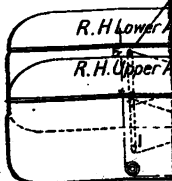
centre of Fuselage. Check by measuring from
g points below outer rear struts, right & left
s must be precisely equal. In plan, leading edges
is equal from end to end of the main cell being
s as indicated in Fig.3. Empannage must be set
in and trailing edges must be perfectly straight

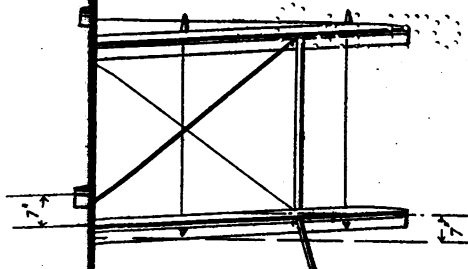
gged so that it points directly in the rear when
rol lever is dead square with the centre line of

ach other laterally and should be rigged so that they
nage when the control lever is perfectly vertical
on.

Dimension X
with correspond
at other side

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CENTRE SECTION ADJUSTMENT.

Vertical & parallel, making bay perfectly square viewed
 by marking spots on exact centres of leading edges,
 lower spots equal distance above upper longerons upper
 from lower spots on all four struts. Each pair of diagonals
 Front Interplane should be exactly equal length see also Fig 1.

ADJUSTMENT.

Plumb line
 leading edge
 upper plane
 ctly balanced about the vertical centre line. Stretch a string
 tip. Adjust landing & flying wires till measurements
 centre section at each side over struts show 8 inches at
 lower plane of outer struts, should be 7 inches above centre
 ges should be perfectly straight & parallel. Check by
 leading edges on upper plane $\frac{1}{2}$ inch from joint with
 as indicated in Fig 2. These should show 8 ft. 3 $\frac{1}{4}$ ins.

ward stagger of 24 ins from end to end of the main
 leading edge of upper plane, one at each side of fuselage
 one up perfectly from the side & each should be exactly
 lower plane

ured between the horizontal and a line joining the centres
 Check with straightedge & spirit level as indicated in Fig 3.
 e of front spar should be 1 $\frac{3}{4}$ ins (see note)

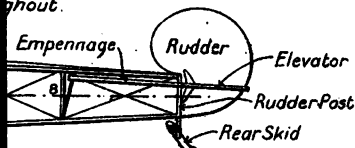
ing wires where necessary, & check again for dihedral
 l. There is no WASH on either wing.



E.

viewed from the side
ical.

is level longitudinally in first three bays.
ghout.



Rudder should be perfectly vertical and point
directly fore and aft when foot control lever
is dead square with centre of fuselage.

vel laterally, check for square using straightedge
gerons near each pair of side struts, making cross
and adjusting side bracing wires till longerons
laterally throughout length of fuselage.

right fore & aft, with top & bottom bracing diagonals
s (6ft from front) upper longerons should be parallel
& dead level in flying position. From a point on
surface of upper longerons stretch a line to the
ed between upper & lower longerons. This line should
their mid points. Adjust by altering side bracing
her & checking again for square at same time.

CENTRE SECTION.

& parallel in flying position making centre bay
the front. Check by measuring diagonals A.D
ould be exactly equal. Check longitudinally by
measuring diagonals as indicated in Fig. 1.

EMPENNAGE AND ELEVATOR.

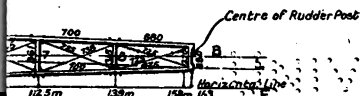
age is set parallel with upper longeron above it
straight & laterally level, showing no wash and
e angle of incidence is $1\frac{1}{2}$ degrees but this can
oring block in fuselage carrying rear spar fixing
e but is designed to lift $\frac{1}{2}$ lb per square foot
ntinuation of empennage with control lever
tion.

Malby & Sons, Lith.

E.

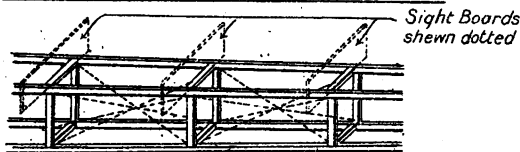
POSITION)

lengths of side bracing Wires.



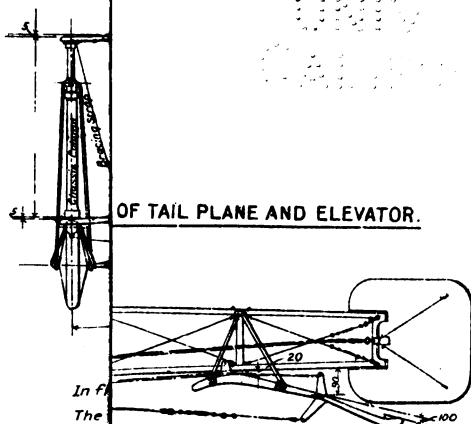
cutting montants 1 at 240 and
 er longerons at each as shewn.
 longerons between points D & E.
 post are taken from this line to
 montants & at each side of Rudder Post
 angle of thrust to the horizontal. This line
 on at the joint as shewn.
 B) should be in a perfectly straight line.

DIAGRAM SHOWING TRUING OF FUSELAGE.



tested for square by means of trammels measuring the interval diagonals
 ated. The 4 diagonals of any one bag should be precisely equal.
 means of 3 sight boards of different colours. These are placed across the
 centres of montants, beginning of montants 3, & by sighting from near any
 ways can be detected & adjusted. Move sight boards from over montants
 & 7 & so on till whole length of Fuselage has been tested & adjusted
 in a similar manner.

Fig.5.



At a weight from 3 to 4 lbs. per square foot of surface. The incidence is adjustable
chassis by steel stay screw adjustment from front & rear spars to top of
at a weight from front spars to bottom of rear spars to top of Montant 6.
& from rear spar & trailing edge of Tail Plane with control bar in vertical
& from trailing edge of elevators to straightedge should be 100 Millimetres

Fig.7. SECTION OF MAIN



FITTING MAIN P

Slip spar in sockets. Bolt up
landing wires to front spar
short, then rear spar onto
dihedral & adjust. Test lat
flying wires first front spar
then warp & balance warp
the check warp wires. The
ribs of French Ash. The
types is fixed by the 30
Measured from centre of
this shows an angle 1 in

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BLEP

ty Rods

Wires

le Anti-Warp Cable.



Columns are not
near above the
to all shock absorbers
for twist must be made
is found to be so great
ing the cross bracing
longitudinal (top, bottom

g or packing the wood

t such a level as to line
s, the leading edges
ther wing be not

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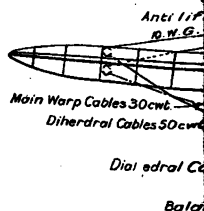
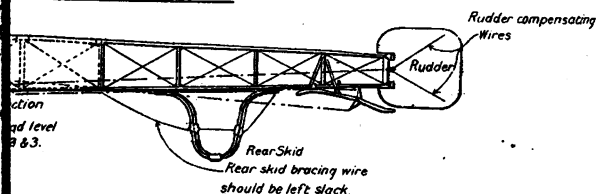


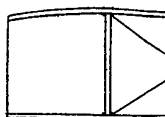
Fig.13.
FLYING POSITION

Elevators to be dead
line with each other &
set with droop as shown
see Fig.10.



Leading edge of tail F
Check by sighting from

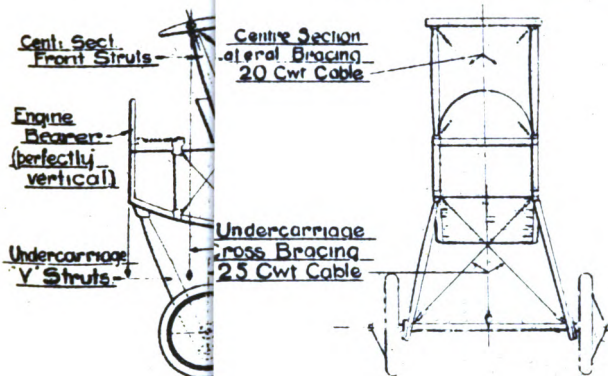
on fix & firmly support control bar in a perfectly
parallel to pilots footboard. To adjust Bottom Pylon
the end of warp bar on control lever through
the warp bar on Pylon should be immediately
using two front stays of pylon.



Adjustment on
Front Stays

No oil to be used to lubricate
rudder control bar. Only
Graphite or French Chalk

Fig. 2.
Front Elevation of Fig. 1.



Undercarriage.

Lateral.

In flying
dead level
exactly
across
wires till

Longitudinal.
and bottom
cross struts
between
in each bay

Adjust by
Check the

Lateral Struts
lines from

Longitudinal.
Check by
section of
spar socket

Note. When fitted
Centre

Lateral

Undercarriage should be perfectly symmetrical about vertical centre line. Check by dropping plumb line from exact centre of fuselage, say mid-points of horizontal strut in first bay, with machine in flying position. Measurements each side of this line to corresponding points right and left should be precisely similar. When true, cross diagonals (front bracing wires) should be exactly equal in length.

Longitudinal. Undercarriage struts do not permit of longitudinal adjustment. For truth, undercarriage depends on correct truing up of fuselage in first two bays. The centre of axle should be 8 inches in front of plumb line dropped from centre of lower front spar socket in flying position.

Note. When fitted with ratwires Undercarriage cross bracings are of $\frac{1}{4}$ B.S.F. ratwire with universal joints type A.G.S. 348.

1

2

3

4

5

6

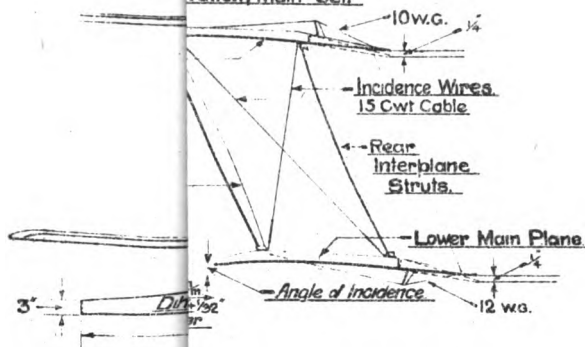
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Fig. 4.
Position, Main Cell



MAIN CELL.

Lateral

Centre of gravity of upper and lower planes of each wing to be perfectly straight and parallel, with stagger constant throughout. Check by dropping four plumb lines from leading edge of upper plane, one at each of fuselage and one at each outer strut. They should all line up perfectly from the side and should be exactly 420 mm or 16 1/2 inches.

Dihedral. (Front of leading edge of lower main plane.

Angle of incidence by altering incidence wires, with all drag. Adjust anti-drag wires slackened off.

Measure

at each angle of incidence at root is fixed by wing differences on fuselage. In flying position, incidence

(Lead be 1 3/4 to 2 1/4 degrees, measured between Dihedral chord of the main planes and the horizontal measured indicated in Fig. 4.

types of

not so since should be constant throughout length Dihedrals. There is thus NO WASH on either wing, in Fig. 3, with straightedge and Abney level, or by care being from the front.

It is of 1/2 inch with Raf wires the following sizes are used the vertical wires (Duplicate) front and rear 1/4 B.S.F. with universal left, front and rear wires (Single) . . . joints type AGS 348 in connecting wires } joints type AGS 347 precise incidence wires } 2 BA raf wire with un- sect. fore and aft bracing }

ator Control.

EMPENNAGE.

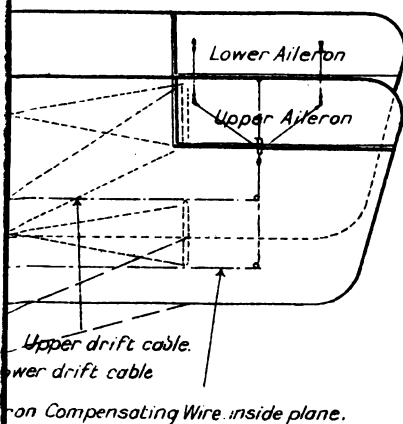
Rudder should type machine with oil tank behind pilots seat and aft whage is of lifting type, and should be set with m/m of Fuselage, measured between level of under surface of and trailing edges giving an angle of about e . In later type machines with tank between centre struts, empennage (lifting type) should be set with

Leading an surface level and parallel with fuselage top longerons plan, and de ted with large non lifting type empennage, in measuring machines, the angle of incidence should be about centre of le e or $15 m/m$ between levels of leading & trailing edges on right at

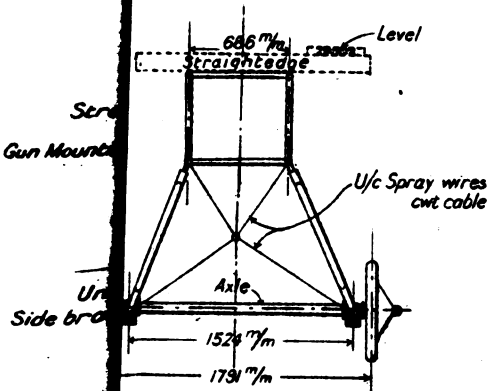
exactly ca
drift cable

ELEVATORS.

on plan.) Aers should be rigged to form a direct continuation of planes nage when control column is perfectly vertical. cables too



2. FRONT ELEVATION.

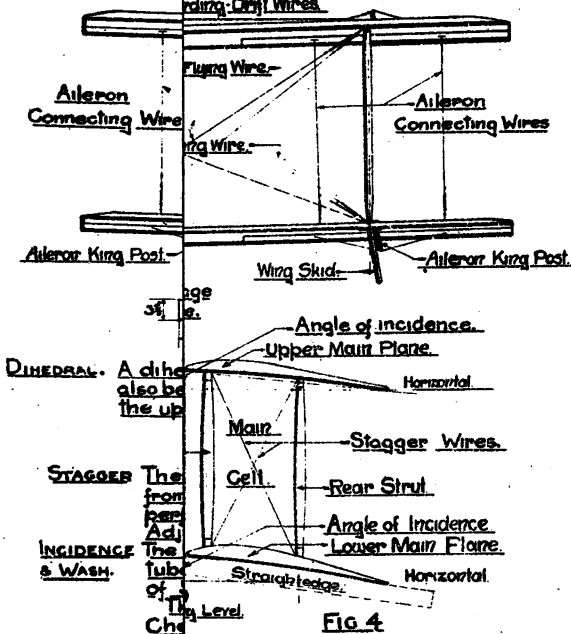


ADJUSTMENT

U/c Frontage should be perfectly symmetrical about
line. Insert distance boards of front & rear
giving 5 ft. centres. Adjust by equalising diagonals
rear; measuring from bolt in socket of upper end
to bolt in socket in centre of skid, lower end of
 Erect and vice versa.
to be
spirally longitudinally by dropping plumb lines from centre
long tube and altering side bracing wires working
together till fore end of aft dimensions agree with

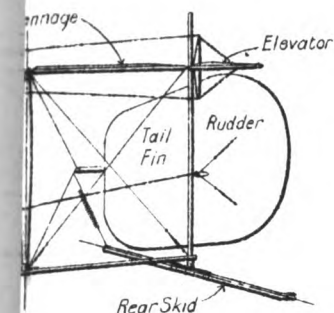
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ATTACHMENT (lateral)
CENTRE SECTION should be perfectly vertical in both
 ends by dead square viewed from the
 cross-lines, and by measuring diagonals.
MAIN CELL. Support
 and catching lines between bolts through
 the outer front & rear struts. Measurements
 and lines to upper surface of front & rear
 wings of each side of centre section. If is
 each dihedral shall be exactly equal each
 by measuring from exact centre of
 lower section to corresponding points on
 lines near tips of lower main planes
 equal.
Leading-Drift Wires



INE,
AILER

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ADJUSTMENT

booms, place spirit level longitudinally on upper
ese should be perfectly level in flying position.
bracing wires The side struts between upper &
must be perfectly vertical, making an angle of 90°

TAIL UNIT

Assm. Check by measuring equal distance each side
pastrut along boom, & equalise diagonals measured
winhe of the strut. see Fig. 5.
ele should be set with spars perfectly horizontal straight
red here should not be No Wash & No Dihedral
to incidence in flying position is about $1\frac{1}{2}^\circ$
uld be set to form a direct continuation of the
en controls are equally tense, & control lever
osition.

△

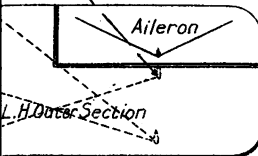
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TAIL UN

*Tail Fin Leading edge set
1 inch to the right see note*

Elevator Control

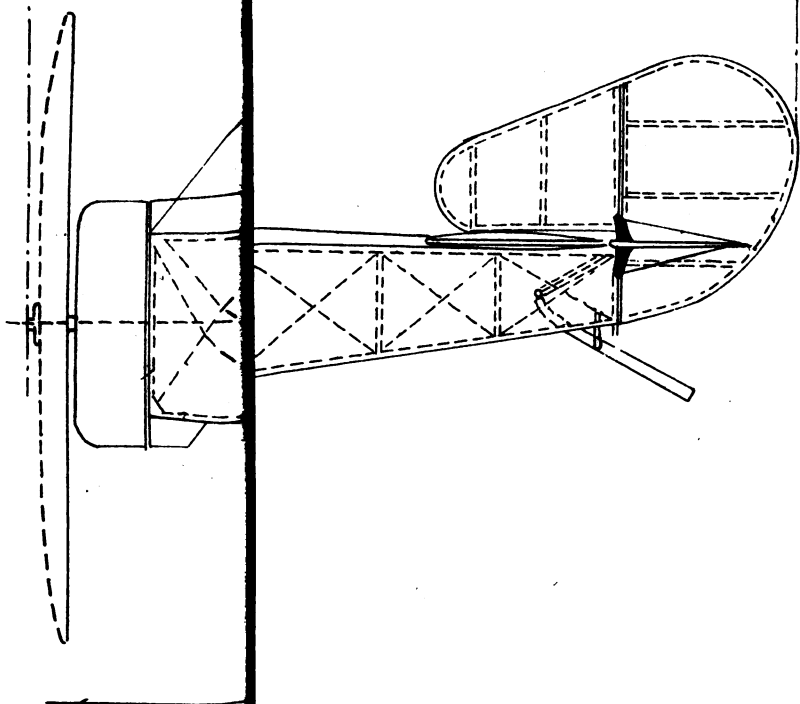
Rudder Control

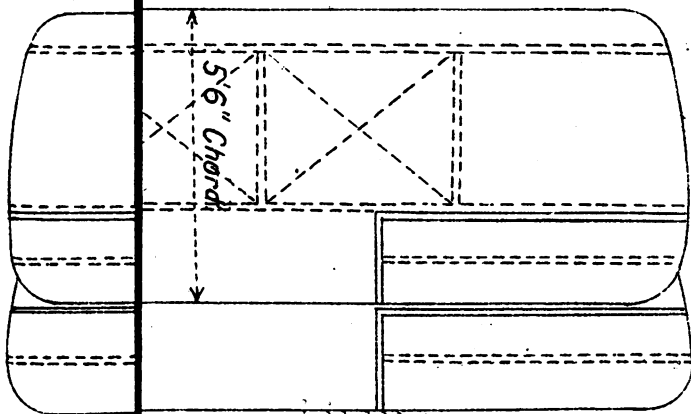


TAIL UN

RUDDER *Rudder should be perfectly
vertical & point directly to
to the rear when controls are
equally tense & foot control
lever is dead square with the
centre of the nacelle.*

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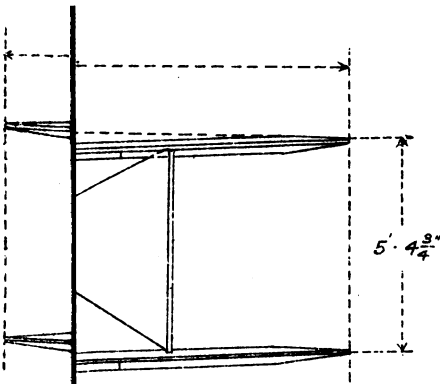


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TER. SOPWITH.

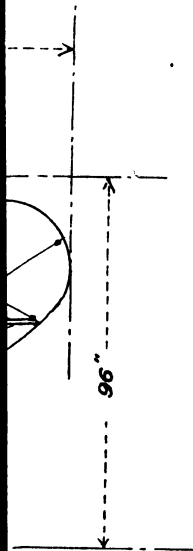
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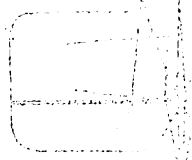
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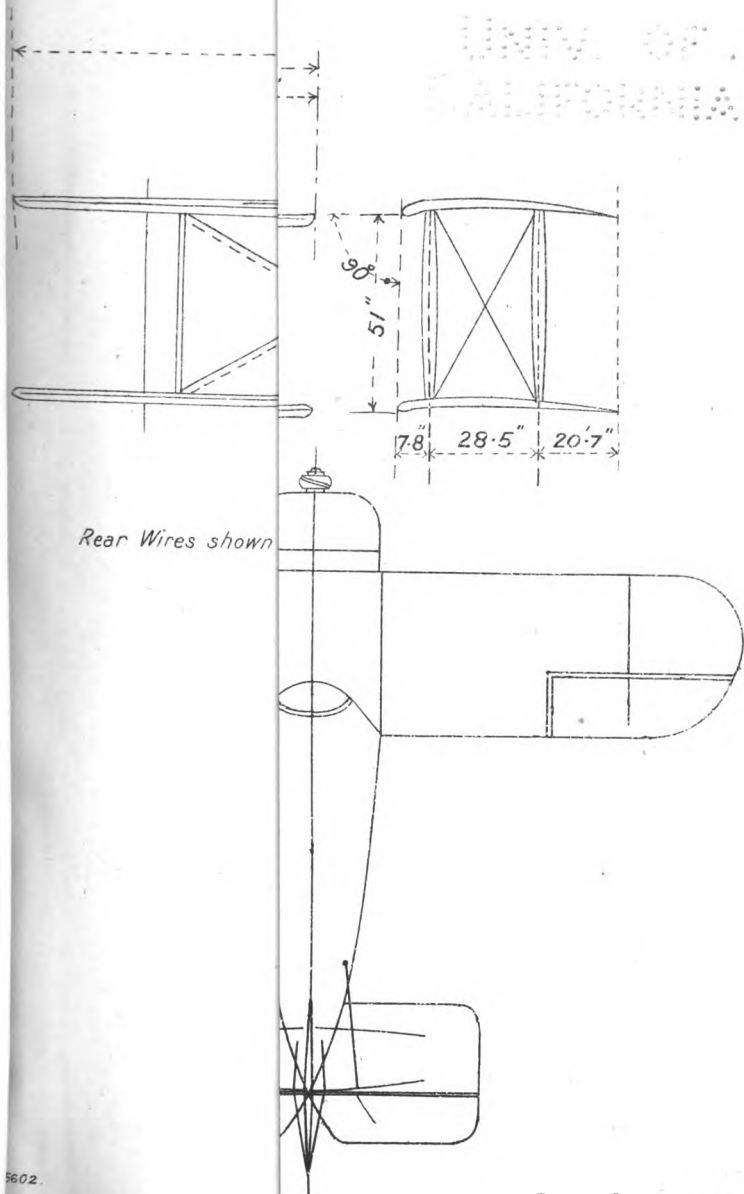


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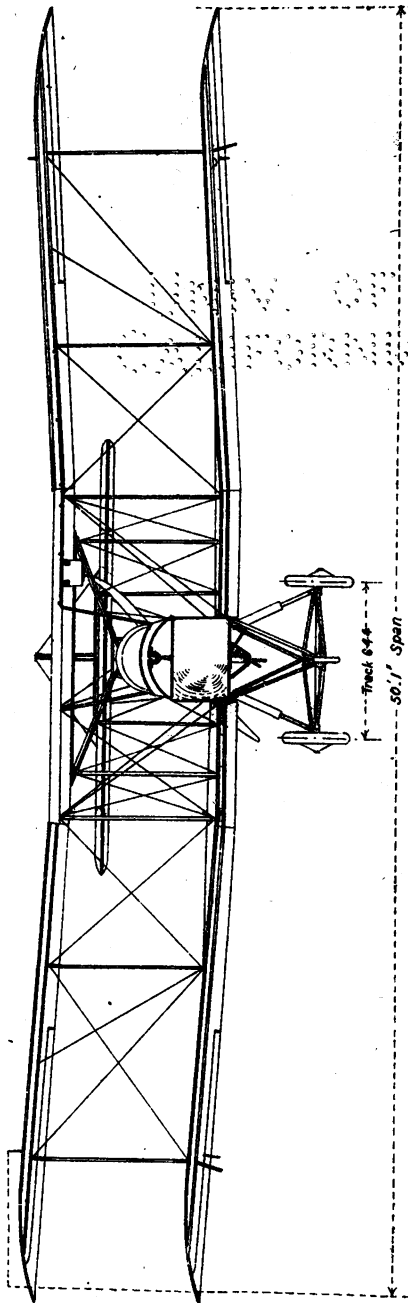
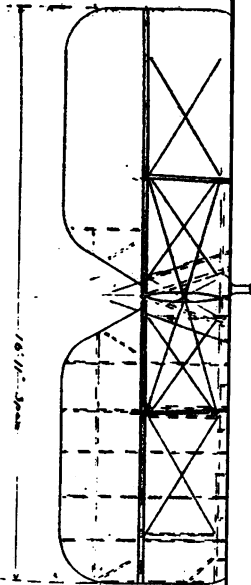
THE
SOPWITH
AIRCRAFT







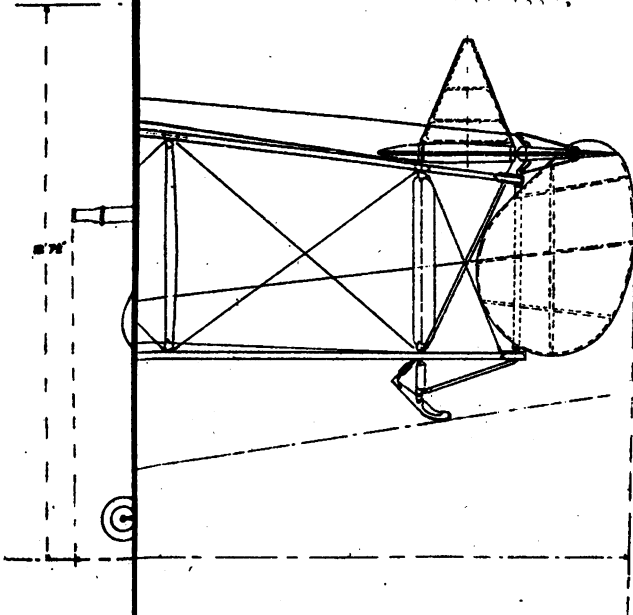
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AEROPLANE F.E.2.B.
FRONT ELEVATION

Plate 33.

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3602

dder

MAIN PLANES: All main plane struts are set at right angles to top rail of nacelle (except rear centre struts in Renault Engine).

DIHEDRAL: A string stretched across top plane between outer struts should measure $5\frac{1}{2}$ " above top of middle struts.

INCIDENCE VARIATION FOR TORQUE: The amount of extra incidence on one side to counteract propellor torque is best proved by practice. (In all cases the incidence must only be varied in outer bay of wings).

AILERONS: Trailing edges should be adjusted to 1° below trailing edges of main planes.

TAIL BOOMS: With top rail of nacelle horizontal and main struts vertical the tail booms should be symmetrical, i.e. the tail boom struts vertical, and making the same angle with the booms top and bottom. The side bracing wire from outer planes to middle tail boom struts should be slack otherwise the tail boom struts will vibrate badly. The machine must not be flown without weight in front.

CHANGING BOTTOM PLANE. 1. Place trestle under rear end of fuselage to take weight of tail skid and under front end of fuselage to balance machine.

2. Disconnect bracing wires from tail boom.

3. Disconnect main plane lift wires.

4. Place trestle under lip of bottom plane and remove landing wire.

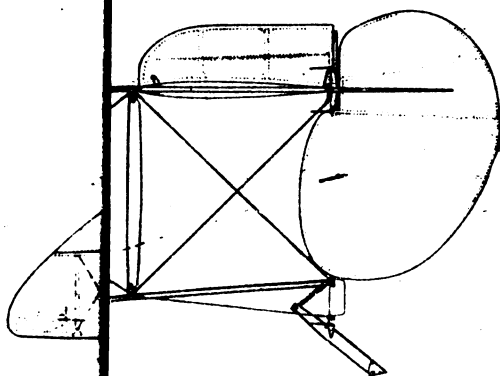
5. Prop up top plane safely.

6. Remove pins from bottom of main plane struts and bolts holding planes to fuselage.

7. Disconnect ailerons. New plane should be laid out on trestles and eyeplates and strut eyebolts should be changed to new plane. Fit new plane as dismantled (reverse of above).

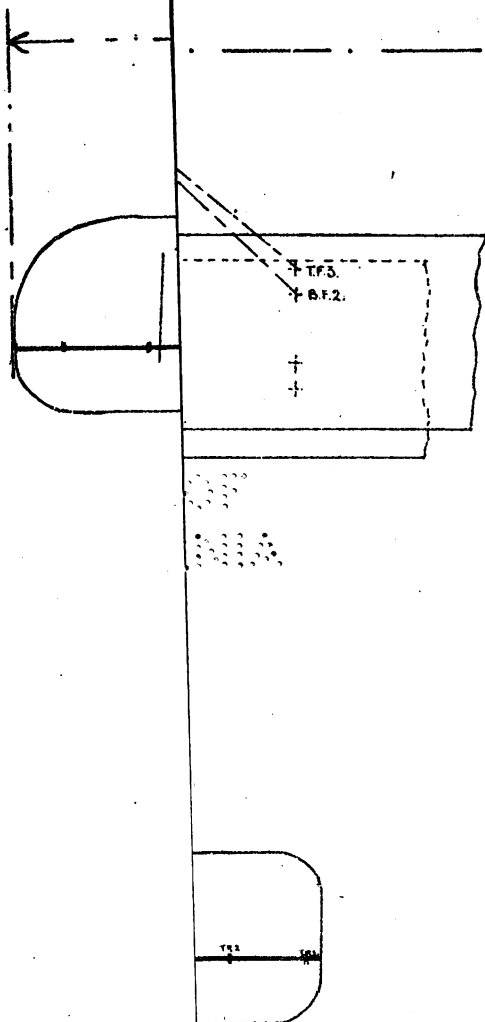
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Plate 35.



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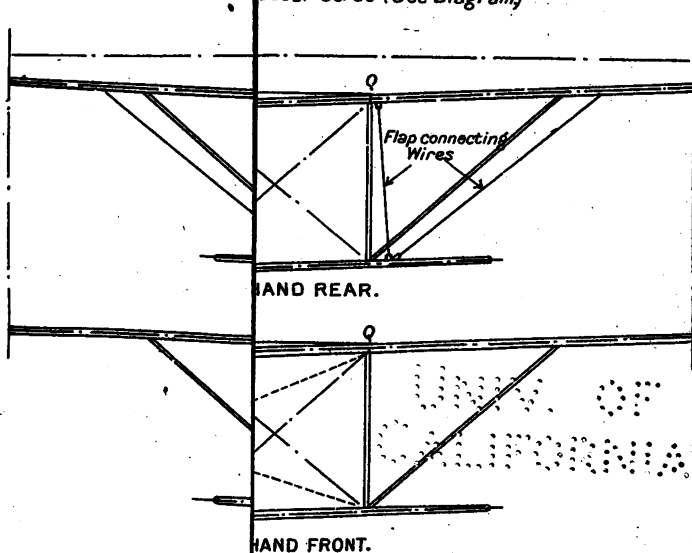
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OF R.E. 7.

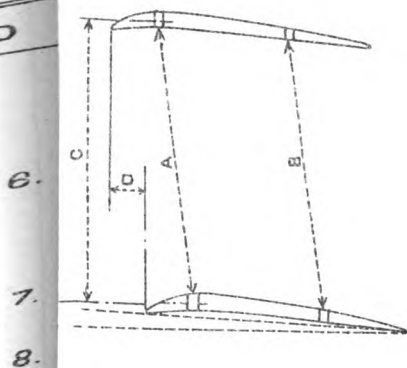
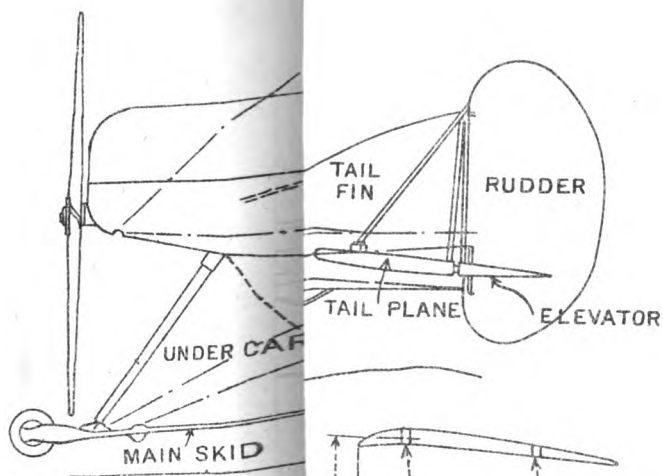
1. S
2. S
3. *M* the distance between
p strut. Distance *Y* is
d outer strut (See Diagram)



4. *A* from *P* to *Q*. the distance
be
5. The strut must be equal
or
- A* centre line of body, is
f Hand wings the R. Hand
w struts is $\frac{1}{2}^{\circ}$ less than at the root.

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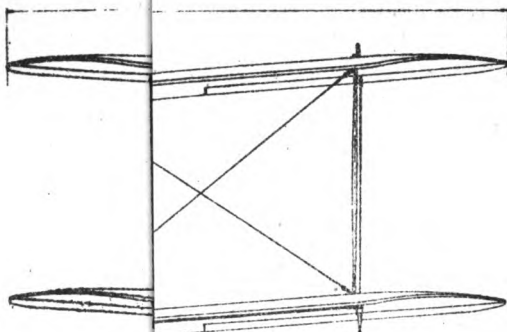
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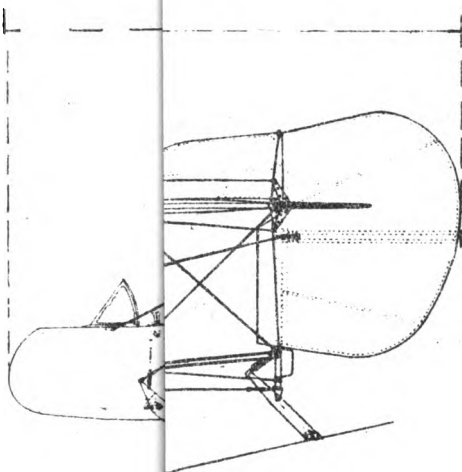


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